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# **A CVCV model of consonant cluster acquisition: evidence from Greek**

Thesis submitted to the University of London in partial  
fulfilment of the requirements for the degree of  
Doctor of Philosophy

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2007

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## **Abstract**

The aim of this thesis is to develop a model of the acquisition of consonant clusters within the phonological framework of CVCV theory. This is the first attempt to link CVCV to the area of language acquisition. It thus provides a new domain within which CVCV can be evaluated against other phonological theories.

The core claim of CVCV is that syllable structure consists solely of onsets and nuclei, without any branching constituents. Consonant clusters are separated by empty nuclei, whose distribution is controlled by binary parameters. The model developed in this thesis is based on the assumption that a central part of the acquisition process is the gradual setting of these parameters to the appropriate value.

The model, apart from covering familiar acquisition data, makes a number of predictions about the order of acquisition of consonant clusters. Of particular importance are predictions regarding word initial clusters of non-rising sonority, whose acquisition has attracted little attention. The predictions are tested against experimental data of cluster production by fifty-nine children acquiring Greek as their first language.

The experimental results indicate that a CVCV model can account for consonant cluster acquisition. With regard to word initial position, the results support the proposed CVCV analysis by providing evidence for the existence of a word initial Onset-Nucleus unit. Moreover, the notoriously complex issue of s+consonant clusters is examined, and new evidence for the structure and markedness of these clusters is provided.

Finally, the results offer a new perspective on a manner dissimilation phenomenon in Greek, whereby clusters of two voiceless fricatives or two voiceless stops turn into a fricative plus stop. A parametric analysis, based on segmental complexity, is proposed, and it is argued that this analysis can explain the acquisition data as well as the historical evolution of Greek clusters.

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## Abbreviations and Notational Conventions

### Abbreviations

ABL	ablative
ACC	accusative
ACT	active
C	consonant
CAUS	causative
DIM	diminutive
ECP	Empty Category Principle
F	feminine
GEN	genitive
gov	government
IG	infrasegmental government
IMP	imperative
lic	licensing
M	masculine
N	nucleus
N	neuter
NOM	nominative
O	onset
Ø	an empty nuclear segment
PERF	perfective
PL	plural
R	sonorant
SF	surface form
SG	singular
SSG	Sonority Sequencing Generalisation
T	obstruent
UF	underlying form
V	vowel
#	word boundary



\* unattested form

Consonant clusters are represented as follows:

TR obstruent-sonorant sequence

RT sonorant-obstruent sequence

TT obstruent-obstruent sequence

sT s-obstruent sequence

sC s-consonant sequence

Throughout this thesis, all transcriptions are italicised, while glosses appear in single brackets (e.g. *fos* 'light').

Children's production forms are given as follows: *target form* → *production form*.

Diachronic change is presented in the following way: *older form* > *later form*.

The phonetic symbols used throughout this thesis have their International Phonetic Association values. Transcriptions are broad and the stress of non-monosyllabic words is denoted by an accent before the vowel that bears it.

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# INTRODUCTION

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This thesis investigates the acquisition of consonant clusters in Greek. It is known that children at the early stages of acquisition tend to produce consonant-vowel sequences, without consonant clusters. Gradually, different cluster types start to appear in various positions. I will be concerned with the order in which Greek speaking children in the age range 2;03-5;00 master the production of different cluster types in word initial and word medial position.

The method of investigation is hypothetico-deductive. I develop a parametric model of cluster acquisition and subsequently test the predictions made by the model with the aid of experimental child language data. The model is based on a phonological theory that has yet been applied to acquisition, namely CVCV theory (Scheer 2000, 2004).

CVCV theory, being couched within the tradition of generative linguistics, assumes that humans are endowed with innate linguistic knowledge in the form of a Universal Grammar (Chomsky 1959, 1986). According to CVCV, this knowledge consists of general principles and binary parameters that control syllabic structure. An important part of the acquisition process is the gradual setting of the parameters to the correct value.

I use CVCV theory claims about syllable structure and parameter dependencies, made entirely on the basis of adult language data, in order to develop a model that makes predictions about the order of acquisition of different cluster types. For example, I test the prediction that word initial clusters of non-rising sonority (TT) are acquired after their word medial counterparts. The prediction is based on the assumption that the marked parameter settings required for word medial

TT clusters to be allowed in a grammar form a proper subset of those required for word initial TT clusters to be allowed. Of particular importance is the comparison of word initial s+obstruent (sT clusters) with other TT clusters. I provide evidence that the production of sT clusters is systematically mastered before the production of TT clusters. This entails that the claim made by many researchers that word initial sT and TT clusters fall into one category must be modified.

The structure of the dissertation is as follows. In the first chapter I provide a brief history of some approaches to syllable structure that have influenced the study of phonological acquisition.

The second chapter of the thesis is concerned with the presentation of CVCV theory assumptions about structure that are relevant to consonant clusters. I also develop a CVCV parametric model of cluster acquisition, and show how the model can account for familiar production data. The presentation of each parameter is paired with the presentation of data from the acquisition of the corresponding cluster. I also briefly discuss some assumptions about the structure of children's phonological grammar and the discrepancy between perception and production in child language.

The third and fourth chapters are devoted to the discussion of cluster acquisition by Greek children. In chapter 3, I provide experimental evidence that word initial TT clusters are acquired after their word medial counterparts, while no such difference exists between word initial and word medial TR clusters. In chapter 4, I discuss the acquisition of sT clusters, in comparison with other cluster types. Since CVCV in its current formulation does not include a separate provision for sT clusters, I propose an auxiliary hypothesis to deal with the acquisition of these clusters. The predictions made are tested and compared with those made by other acquisition models. I provide experimental evidence that word initial sT clusters behave differently from word initial TT clusters in acquisition. I also argue that the CVCV parametric model, contrary to other approaches, can help explain the paradox whereby initial sT and TT show different behaviour in their acquisition, without exhibiting such differences in adult phonology. Further predictions regarding order of acquisition that are tested experimentally include comparisons of word initial versus word medial sT and of sT versus TR. I also provide experimental evidence against the existence of an implicational universal concerning codas and complex onsets.

In the fifth chapter, I discuss the segmental details of consonant clusters, focusing on the link between language acquisition and language change. I suggest that a change of a parameter setting was responsible for the emergence of lenition in Greek, and I provide experimental evidence for the effects of the parameter on the acquisition of Greek.

The dissertation closes with a general conclusion.

# CHAPTER 1. APPROACHES TO SYLLABLE STRUCTURE AND ITS ACQUISITION

---

## 1 Introduction

Generative phonology has had a great influence on the way child language is viewed and studied. Whenever a new phonological theory was developed, a number of acquisition studies would make use of the new advances in the field. In this chapter I discuss some of the advances of phonological theory relevant to syllable structure and corresponding acquisition studies, with focus on consonant cluster acquisition. Acquisitionists' approaches to clusters have often been direct reflections of phonologists' claims about syllable structure. Acquisition models have been designed to follow the types of structure proposed by research on adult phonology and clusters were examined as parts of such structures. When phonology denied the existence of any such structure (as for instance in Chomsky & Halle (1968)) so did the study of cluster acquisition.

The chapter proceeds as follows. After an introduction in section 1, section 2 presents Chomsky & Halle's *Sound Pattern of English* (1968), which denies the existence of the syllable as a phonological object, and Smith's (1973) acquisition research. Section 3 presents a version of syllable structure that involves (word medial and word final) coda consonants, and corresponding acquisition research, while section 4 presents the Government Phonology view of syllable structure, whereby word final consonants are onsets, and Pan's (2005) acquisition study in Government Phonology. Finally, section 5 introduces CVCV theory with its basic premise that all consonants are onsets, in anticipation of chapter 2 where I apply CVCV theory to language acquisition. A short conclusion follows. In examining

how syllable structure is constructed, I also discuss notions such as sonority and complexity.

## **2 SPE: syllable-free phonology**

### **2.1 The framework**

The work that marked the beginning of generative phonology, *The Sound Pattern of English* (SPE, Chomsky & Halle (1968)), denied the necessity of the syllable as a representational unit. Chomsky and Halle viewed segments as matrices of features and their representations consisted of strings of such matrices, excluding any higher-level structure. Rewrite rules, which were the formal expression of phonological processes, could only refer to the feature matrices.

The desire to achieve formal simplicity led to the abolition of any direct reference to syllabic constituency. The way to capture syllabic effects in a linear framework like that was the use of the feature +/- syllabic, thus indirectly admitting the syllable into the theory.

Even though soon thereafter linguists began to be concerned about potential problems of such an approach, such as overgeneration, the model suggested by Chomsky & Halle had a huge impact on linguistic thought.

### **2.2 Acquisition after SPE**

Indeed, shortly after the SPE was published, researchers applied the model to the study of language acquisition. In one of the most influential works of this type, Smith (1973) analyses the phonological development of his son Amahl using SPE notation, types of rules and features.

While Smith does not make reference to constituency and syllabic structure in his analysis, he expresses the idea that ‘the postulation of a *syllable* would simplify the statement of restrictions on the distribution of consonants in words’ (Smith 1973: 171).

### 3 The syllable

#### 3.1 Codas

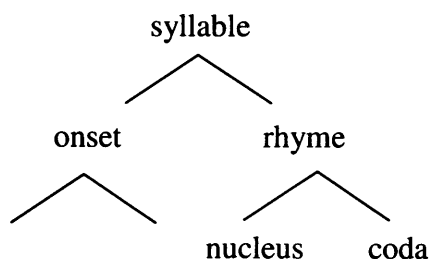
As phonological theory progressed, a series of phenomena in several unrelated languages led linguists to assume that segments were organised in higher level constituents, one of which is the syllable. The range of observations that led to this conclusion is wide, including native speaker intuitions, language games, distributional facts and phonological processes.

The argument probably most cited, to the extent that it is a standard textbook example (Carr 1993; Ewen & van der Hulst 2001; Roca 1994), is the coda phenomenon. The environment ‘before another consonant or word-finally’ appears again and again in phonological processes. For example, in many English dialects, *l* is velarised preconsonantly and word finally, so that words such as ‘mole’ and ‘moulding’ have a velar *l*, while ‘molar’ has a plain (non velar) *l*. In the SPE formalisation, velarisation would be stated with the double environment  $\left\{ \begin{array}{c} C \\ \# \end{array} \right\}$ ,

which is undesirable not only because it is a disjunction, but also because it treats on a par a boundary symbol (#) with the phonological entity of the segment.

The realisation that consonants in a preconsonantal and word final position have something in common led to the unified representation of the two as codas in a hierarchically organised syllable. Although a variety of syllable models have been proposed (see Blevins (1995)), the one often presented as the standard one (see for example Goldsmith (1990)) is the following:

#### 1. The syllable



Under this view, the syllable is divided into onset and rhyme, and the rhyme is in turn composed of the nucleus and coda constituents. The organisation of this model offers a different, hierarchical perspective on the nature of phonological phenomena.

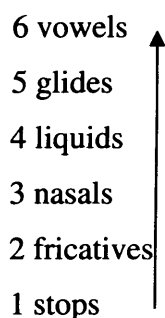


In the case of the velarisation phenomenon mentioned above, for example, preconsonantal and final *l* are velarised not because of what precedes or follows, but because they belong to the coda constituent. This way the problematic disjunction is avoided and no reference to word boundaries is made.

### 3.2 Sonority

The idea of the syllable requires a mechanism that can decide how the structure will be assigned to the string of segments. In the various forms syllabification mechanisms have taken, they have been largely based on the notion of sonority. Sonority is impressionistically defined as the relative loudness of sounds (Ladefoged 1975), or the degree of articulatory opening that the production of a sound requires (Saussure (1916) et passim). It is argued that its most reliable physical measure is intensity (Parker 2002). It is often given as a scale, whose core looks as shown in 2:

#### 2. The sonority scale

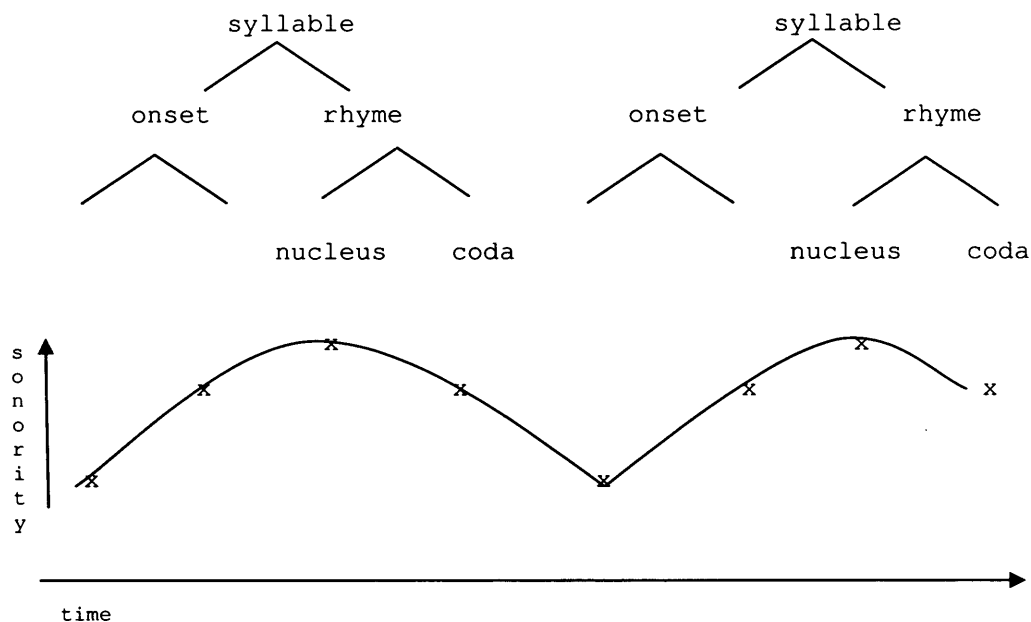


Different formalisations of the scale have been proposed. Selkrik (1984) for example, postulates sonority indices corresponding to major classes of sounds (see also Steriade (1982) for a more fine-grained sonority scale).

Syllabification is achieved with the combined action of the numerical value and a number of principles or rules that decide the requirements of the structure for sonority value distances. As a general rule, the peak of the syllable, the nucleus, demands segments of as high sonority as possible, preferably vowels, and less sonorous segments are preferred as one moves towards the syllable edges. This has become known as the Sonority Sequence Generalisation (SSG, see Clements (1990) for a historical overview) and renders syllables such as *pla* preferable to *lpa*, since the latter does not follow the generalisation, having a sonority profile that falls and

then rises again. The SSG results in continuous cycles of rising and falling sonority, as shown below:

### 3. The sonority cycle



The preferred sonority profile of a syllable ‘rises *maximally* from the beginning to the peak, and falls *minimally* from the peak to the end’ (Clements 1992). Thus, for example, a syllable such as *pal* is better than *lal*, because its onset is less sonorous, also better than *pap*, because its coda is more sonorous.

In order to capture this and further restrictions that languages have been observed to impose on syllable organisation, various principles have been proposed, such as the Maximal Onset Principle (Selkirk 1982) and the Syllable Contact Law (Murray & Vennemann 1983), or a combination of a Core Syllabification Principle combined with the Dispersion Principle (Clements 1990, 1992). Such mechanisms are fed with the relative sonority values to decide upon syllable structure.

### 3.3 Acquisition in the coda-sonority era

Researchers in the field of first language acquisition have been greatly inspired by the notion of syllabic organisation, and particularly by the role of sonority. Several studies (Gierut (1999), Ohala (1998, 1999), Zamuner (1998), Zamuner & Gerken (1998) among others) were conducted to test the Sonority Hypothesis in acquisition, which states that ‘children reduce clusters in such a way that the resulting syllable

exhibits the most optimal sonority contour' (Ohala 1999). Word initial and word medial clusters are expected to reduce to whichever consonant in the cluster creates a maximal sonority distance, that is the least sonorous one, and word final clusters to whichever consonant in the cluster creates a minimal sonority descent, that is the most sonorous one.

For example, Ohala (1998) examined the medial clusters of children acquiring English and found that the least sonorous consonant of the cluster was preserved after reduction, irrespective of the order of the consonants. In a word like 'zebra', for instance, preservation of the *b* was significantly higher than preservation of the *r*, and similarly for the *rp* of 'carpet'. This, according to Ohala, supports the hypothesis that children syllabify strings as CV.CV, and choose the least sonorous consonant for the onset, since that would produce the maximal rise in sonority that the SSG requires.

Moreover, acquisition researchers became interested in the acquisition of syllable structure with its various components. Fikkert (1994) develops a Principles and Parameters model (Chomsky 1981, 1986) for the acquisition of Dutch syllable structure. The model assumes a number of (usually binary) parameters that determine syllable structure, and views acquisition as the gradual setting of these parameters to the appropriate value. Fikkert posits a default-initial setting for each parameter, which switches to the marked setting in later stages of acquisition. Two such parameters are given in 4 and 5. The default value is underlined.

#### 4. Onset parameter

- a. Number of onsets is equal to 1 [On = 1]
- b. Number of onsets is equal to or smaller than 1 [ $\text{On} \leq 1$ ]
- c. Number of onsets is equal to or smaller than 2 [ $\text{On} \leq 2$ ]

#### 5. Branching rhyme parameter

Rhymes can branch into a nucleus and a coda [No/Yes]

According to the Onset parameter, the first developmental stage has an obligatory single onset. Later the onset becomes optional and finally complex onsets appear. An example of this gradual parameter is given in 6-8. Jarmo, one of the children studied by Fikkert, produces only simple onsets up to the age of roughly one year six months

(6a-6c), when he starts producing onsetless syllables (7). Finally, towards the end of his second year, he starts producing complex onsets (8).

6. [On = 1]

- a. *da:r* → *da*      'there'      (1;04)
- b. *kla:r* → *ka:*      'ready'      (1;05)
- c. *'o:to:* → *'to:to*      'car'      (1;06)

7. [On ≤ 1]

- a:p* → *a:p*      'monkey'      (1;07)

8. [On ≤ 2]

- kla:r* → *kla:*      'ready'      (1;11)

The Branching rhyme parameter captures the observation that children at first produce CV syllables, and only later do they start producing coda consonants. Some data from Jarmo show the two developmental stages, the initial stage with codaless syllables (9) and the subsequent coda production (10).

9. [Branching rhyme No]

- dit* → *ti, tii*      'this'      (1;05)

10. [Branching rhyme Yes]

- a:p* → *ap, a:p*      'monkey'      (1;07)

Fikkert's influential study was followed by other studies, which share a similar view of syllable structure (e.g. Levelt et al (2000), Levelt & van de Vijver (2004)). These two studies investigate Dutch children's acquisition of syllabic structure using the data used in Fikkert's study – namely, the Fikkert-Levelt corpus of child language (Fikkert 1994; Levelt 1994; MacWhinney 2000). However, they do not follow a parametric framework. Instead, they adopt Optimality Theory (Prince & Smolensky 1993), which is based on the idea of violable universal

constraints on representations<sup>1</sup>. Constraints are universal but the ranking of these constraints is language specific, and the language acquisition task is to set the constraints in the target order. The following constraints, used by Levelt et al (2000) are the Optimality Theory equivalent of the parameters in 4 and 5.

11. ONSET	Syllables should have an onset
NO-CODA	Syllables should not have a coda
*COMPLEX ONSET	Syllables should not have a complex onset

These constraints interact with Faithfulness constraints (FAITH), which demand identity of input (in this case, the adult form) and output (child's production) are identical. Consider the cases of the two possible rankings in 12.

12. a. ONSET, NO-CODA, \*COMPLEX ONSET >> FAITH  
 b. \*COMPLEX ONSET, ONSET >> FAITH >> NO-CODA  
     >> ranked higher than  
     , unranked with respect to

The ranking in 12a involves Faithfulness constraints ranked lower than all other constraints<sup>2</sup>. It describes a stage when only CV syllables are produced. In Fikkert's terms, this corresponds to a stage when the Onset parameter (4) is set to 1 and the Branching rhyme parameter (5) is set to No. The ranking in 12b corresponds to

---

<sup>1</sup> In Levelt et al (2000) Optimality Theory is used in conjunction with a view of syllable structure similar to that described in section 3.1. However, the Optimality Theory framework, with its core assumption of constraint interaction (as opposed to rules, or principles and parameters) can be used in conjunction with any theory of syllable structure. Indeed, Optimality theory has been used in a number of acquisition studies that may not share the same view on syllable structure (Gnanadesikan (1995), Bernhardt & Stemberger (1998), Demuth (1996), Pater (1997), Rose (2000), Barlow (1997) among others) or even ascribe a considerably diminished role to syllable structure in the phonological acquisition task (Vanderweide (2005), see chapter 3). For this and other reasons, Optimality Theory has been criticised as a theory of phonology (see Dresher (1996), van der Hulst (2000), Rennison (2000), Ploch (2003)).

<sup>2</sup> This type of ranking, with faithfulness constraints ranked lower than the rest (markedness constraints), is commonly assumed to be the initial stage in Optimality Theoretic studies (Gnanadesikan (1995), Tesar & Smolensky (1998, 2000) among others). See, however, Hale & Reiss (1998) for the opposite suggestion.

Fikkert's Onset parameter set to 1 and the Branching rhyme parameter set to Yes. At this stage the child produces CV and CVC syllables.

All these acquisition studies are based on the notion of sonority and the type of syllable structure described in section 3.1.

## 4 Government Phonology

### 4.1 Complexity

Although the SSG has been widely used and is generally accepted, it has not been free of criticism. Apart from the fact that the phonetic specification of sonority is controversial, there is concern that there is no independent phonological motivation for sonority. The sonority scale in 2 is often presented as an arbitrary look-up table designed to encode the distributional observations (Harris 1994, for further arguments see also Harris (2006)). The question then arises whether the facts sonority is designed to deal with can be linked to other aspects of the phonological system, which would serve as independent evidence to any analysis proposed.

A possible step in this direction is an approach where distributional facts and phonological processes are linked together, both depending on fundamental properties of the segments. Such a suggestion can be found in Element Theory (Harris 1990, 1994), which claims that segments are made out of monovalent primes<sup>3</sup>. The elemental make-up of segments can be seen in phonological processes. For instance, lenition processes show the gradual loss of elements on the way to zero<sup>4</sup>. The example that follows (after Harris 1990) shows a typical lenition process in English (see for instance spirantisation in Liverpool vernacular English: *bes* 'bet', *æh* 'at'), but also in Spanish, Burmese and Malay, where the *t* undergoes a gradual decrease of complexity<sup>5</sup>.

---

<sup>3</sup> I provide no list of primes, since there is no consensus as to which these primes are. Some contributions to the debate can be found in Harris (1990, 1994), Harris & Lindsey (1995), Kaye (2001), Rennison (1999a), Scheer (1999), Szigetvári (1994).

<sup>4</sup> Phonological processes argued to be linked to the elemental make-up of segments also include, for example, vowel reduction (Harris 1994) and vowel harmony (Charette & Göksel 1994).

<sup>5</sup> This analysis refers in the first instance to the historical development of sound changes. In synchronic terms, lenition is viewed as one of the factors determining consonantal alternations or distributions (Harris 1994).

### 13. *t* lenition

a)      b)      c)      d)  
 t → s → h → ∅

x	x	x	(x)
<b>h</b>	<b>h</b>	<b>h</b>	
<b>R</b>	<b>R</b>		
?			

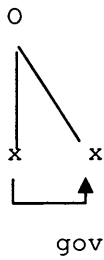
According to this approach, the property that is responsible for the distributional observations is complexity, which corresponds to the number of monovalent primes that a segment consists of. The fundamental difference between sonority and complexity is that complexity has independent motivation and definition, since it reflects the internal composition of segments, which is responsible for other phonological facts and processes, while sonority does not.

Following this reasoning, Government Phonology (Charette 1990; Harris 1994; Kaye, Lowenstamm, & Vergnaud 1985, 1990) saw syllabic structure as the result of the combination of complexity and a number of relations that can be established between syllabic positions<sup>6</sup>. The relation mostly relevant to us at this point is government, which is asymmetric and holds between adjacent positions, one of which is the governor and the other the dependent. Such a relation holds, for example, between the two members of a complex onset (14a), or an onset and the preceding coda<sup>7</sup> position (14b).

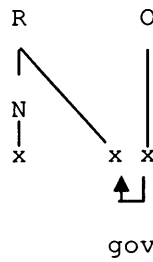
<sup>6</sup> Other phonological models that rely on monovalent primes are Dependency Phonology (Anderson & Ewen 1987) and Particle Phonology (Schane 1984).

<sup>7</sup> Government Phonology does not recognise coda as a constituent, as seen in 14b. However, this does not affect our present discussion.

14. a. Complex Onset



b. Coda-Onset



An essential requirement for these asymmetric relations to be established is expressed in the complexity condition given in 15 below.

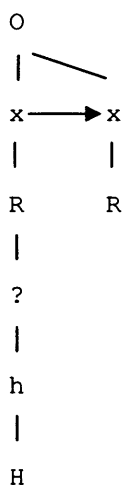
15. Complexity condition (Harris 1990)

Let *a* and *b* be segments occupying the positions A and B respectively.

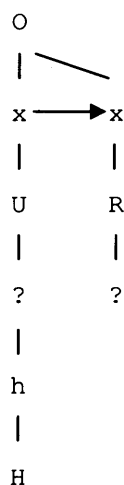
Then, if A governs B, *b* must be no more complex than *a*.

The effect of this condition can be illustrated by the following examples, which show a downward complexity slope within a complex onset (Harris 1994).

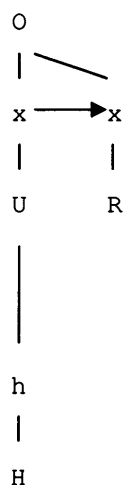
16. tr



pl



fr



As we can see in 16, the head of the government relation, in this case the obstruent, the first member of the complex onset, is more complex than the governee. Were the order of the segments the reverse, this type of governing relation could not be established (see Kaye (1990) and Harris (1990) for discussion on directionality of government), and no complex onset structure would be constructed. This mechanism



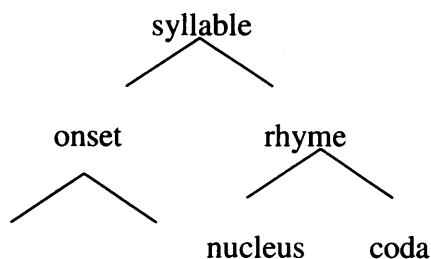
is responsible for the difference in the distribution of sequences like *pla* versus *lpa*, discussed in section 3.2.

In sum, complexity, combined with government, can capture the observations that sonority models deal with, and it presents the advantage of having an independent definition.

## 4.2 Word medial versus word final codas

Having presented in the previous section how syllable structure is determined according to Government Phonology, we now discuss what the structure actually looks like in this framework. From the differences of Government Phonology with other syllable theories, the one we shall concentrate on is the issue of word final codas. As shown in 1, repeated here for convenience as 17, in standard syllable theories the syllable consists of an (optionally branching) onset and a rhyme, which (optionally) branches into nucleus and coda. The coda branch is used not only for word internal codas, but also for word final consonants. Recall that the similarity between internal and final codas was actually one of the arguments for the existence of syllable structure.

17. The syllable



However, there have been a number of studies claiming that word final and word medial codas are not the same (e.g. Charette (1991), Gussmann & Harris (1998, 2002), Harris (1994), Kaye (1990)). The arguments used come from a variety of languages, and include typological and stress facts, as well as effects on preceding vowels and the consonants themselves.

I present here one example, concerning vowel length in English (Gussmann & Harris 2002). The term Closed Syllable Shortening in English describes the situation where a coda consonant forces a preceding vowel to be short. While the

possibility of having a long nucleus and a coda consonant (a super-heavy rhyme) exists, there are heavy restrictions on the type of consonant allowed in such a context word internally (for example, the consonant must be either a fricative or a sonorant, if it is a sonorant, it must be homorganic with the following onset and so on). Word finally, though, such restrictions do not hold, something that is surprising if the final consonant is a coda. And not only that, but there are alternations involving vowel length, of the following type: long nucleus before a final coda, which appears short when it is before an internal coda (examples from Gussmann & Harris (2002)).

#### 18. English closed syllable shortening

Final coda		Medial coda	
<i>pəsi:v</i>	‘perceive’	<i>pəs<sup>1</sup>eptɪv</i>	‘perceptive’
<i>dɪskr<sup>1</sup>aɪb</i>	‘describe’	<i>dɪskr<sup>1</sup>ɪpʃn</i>	‘description’
<i>rɪdʒ<sup>1</sup>u:s</i>	‘reduce’	<i>rɪd<sup>1</sup>ʌkʃn</i>	‘reduction’
<i>waɪz</i>	‘wise’	<i>w<sup>1</sup>ɪzdəm</i>	‘wisdom’

Such phenomena can be explained<sup>8</sup> if we follow the assumption that word final consonants are onsets of a syllable that contains an empty nucleus. According to this view, two structures that involve internal and final ‘codas’, would be as shown in 19a and 19b respectively (the position of the relevant consonant in bold):



An internal coda consonant is followed by an onset (19a), while a final consonant is itself an onset and is followed by an empty (unexpressed) nucleus (19b). For the sake of clarity, I illustrate the two structures with actual words.

<sup>8</sup> For an earlier attempt to capture these phenomena see Itô (1986), cf. Gussmann & Harris (2002).

20.	a. Coda					b. Final consonant				
	O		R			O		R		
			N					N		
	x		x		<del>x</del>	x		x		x
	h		e		f	t		i		

The hypothesis that word final consonants are onsets can explain the facts of English closed syllable shortening in 18. A vowel is free to be long before an onset, as in *pəsi:v*, before the word final onset, while it has to be short before a coda, as in *pəs'eptɪv*.

In this section, we have seen how Government Phonology has captured the fact that internal and final ‘codas’ do not behave the same by claiming that the final ones are not codas but onsets followed by an empty nucleus.

### 4.3 Government Phonology acquisition

Government Phonology claims have been used in language acquisition studies (Pan 2005; Pan & Snyder 2003, 2004). Pan (2005) analysed the data used in Fikkert’s (1994) study using Government Phonology principles and parameters. Amongst the parameters she uses, the following are relevant to our present discussion (in Pan’s model, like Fikkert’s, all parameters have a default value and a marked value – default values are underlined).

21. Branching onset parameter: Onsets may branch [No/Yes]

Empty nucleus parameter: Empty nuclei are allowed [No/Yes]

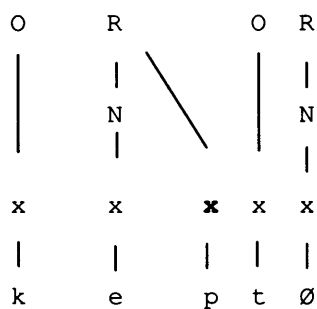
Branching rhyme parameter: Rhymes may branch [No/Yes]

The Branching onset parameter corresponds to Fikkert’s Onset parameter, in determining the number of consonants an onset can consist of. The Empty nucleus parameter regulates the existence of word final consonants. In the default (No) value, the parameter does not allow word final consonants, which would involve a final

empty nucleus. Only when the Empty nucleus parameter is switched to the marked (Yes) value do word final consonants appear, in structures like 20b.

Pan introduces the Branching rhyme parameter in order to account for the acquisition of word final consonant clusters, which, according to Government Phonology, consist of a coda plus an onset (followed by empty nucleus) (Kaye 1990).

## 22. Word final consonant cluster



Following Kaye's representation, Pan argues that a Yes value of the Branching rhyme parameter (and a Yes value of the Empty nucleus parameter, see discussion in chapter 2, section 5.3) is required for the existence of word final consonant clusters.

What Pan does not mention, but follows from her analysis and the Government Phonology principles, which her analysis respects, is that the Branching Rhyme Parameter does not control only word final clusters: it also regulates the existence of word medial coda consonants. As we have seen in 19a, word medial codas in Government Phonology are also parts of branching rhyme structures, just like more traditional models assume. In this respect, the Branching rhyme parameter is equivalent to Fikkert's Branching rhyme parameter (5).

A crucial difference, however, is that Fikkert's Branching rhyme parameter is also responsible for the existence of word final consonants (which in the syllable model she follows are also codas), while in Pan's system word final consonants are controlled by a different parameter (Empty nucleus parameter). A consequence of this difference is that the acquisition of word medial codas is now dissociated from the acquisition of word final consonants. The two are controlled by two different parameters (the Branching rhyme parameter and the Empty nucleus parameter respectively), contrary to Fikkert's analysis, in which a single parameter (the Branching rhyme parameter) controls them both.

The existence of a single ‘coda’ parameter, as in Fikkert’s analysis, would lead us to expect simultaneous acquisition of word medial codas and word final consonants. However, developmental data do not seem to follow this prediction. For instance, Jarmo’s production data in 23 indicate that the child could not produce word medial codas long after his mastery of word final consonants.

23. a. Word final consonant

<i>a:p</i> → <i>ap</i> , <i>a:p</i>	‘monkey’	(1;07)
<i>pu:s</i> → <i>pu:s</i>	‘puss’	(1;07)
<i>bal</i> → <i>bal</i>	‘ball’	(1;11)

b. Medial codas

<i>'rarkəns</i> → <i>'kakəs</i>		
→ <i>'fakəs</i>	‘pigs’	(2;0)
<i>'vɪp,vap</i> → <i>'pɪpa</i>	‘seesaw’	(2;0)

The examples in 23a show production of word final consonants starting at the age of one year seven months, and 23b shows that word medial codas were still not produced five months later, at the age of two years. Fikkert notices the inconsistency, and in a footnote (p. 171), after speculating that it may be related to independent factors (such as overall word complexity), she leaves the issue for further research.

In Government Phonology, on the other hand, such data are predicted. The relevant consonants in 23a and 23b belong to different structures (word final onsets and word medial codas respectively), are regulated by different parameters (the Empty nucleus parameter and the Branching rhyme parameter respectively), and are thus expected to be acquired at different points in time, which is what Fikkert’s data show.

In this section, I presented some work on first language acquisition based on Government Phonology syllable analysis.

## 5 CVCV: bringing the facts together

In our discussion, the following paradox, concerning codas, has arisen. The conclusion we came to in section 4.2 is that word final and word medial codas are

different, and that was part of the motivation for Government Phonology to claim that the final ones are in fact onsets. However, the set of differences stands side by side with another set of observations, mentioned in section 3.1, which support the idea of the existence of codas both word internally and word finally. The two sets of arguments seem to contradict each other, supporting either this or that position (Piggott 1991). The only way out seems to be a parameterisation of structure: it has been suggested that some languages allow word final onsets and others word final codas (Piggott 1999).

However, before endorsing such a position, which would weaken one of the basic claims of Government Phonology, namely that there are no word final codas, let us remember how syllable structure is determined according to Government Phonology. As we saw in section 4.1, structure is decided upon according to complexity and relations that hold between syllabic positions. Thus, the determining factor is the horizontal-syntagmatic dimension of asymmetric relations, diminishing the importance of vertical-arborial structure. Governing relations, as we have seen (and licensing, about which more in chapter 2, section 4.2), largely determine the vertical-arborial structure.

After the position that arborial structure is to some extent a consequence of the syntagmatic dimension has been adopted, the next natural step would be to formulate relations in such a way that the arborial structure is completely redundant, and in so doing to get rid of the vertical dimension altogether. Such a step was indeed taken by Takahashi (1993, 2004). Takahashi, using evidence from stress systems and reduplication, argues that there is no convincing evidence for the existence of a syllable node or any sub-syllabic constituent node, and phonological regularities can be captured by reference to syntagmatic relations only. Similarly, Lowenstamm (1996), argues that the vertical dimension need not exist, and the only structure required is a sequence of onset and nuclear positions, a CVCV pattern. All the syllabic phenomena are consequences of a system of parameterised syntagmatic relations. Thus, the generalisation that no word ends in a coda holds, since all words must end in a nucleus, be that filled or empty, so all final consonants are followed by an empty nucleus (24b). Moreover, word internal preconsonantal consonants ('coda' consonants) are necessarily followed by an empty nucleus ( $\emptyset$ ), as is shown schematically in 24a (relevant position in bold).

24. a. Preconsonantal consonant

O N O N  
| | | |  
x Ø x x

b. Final consonant

O N  
| |  
x Ø

The different phenomena described in earlier sections originate in the parameterised syntagmatic powers of nuclei, namely government and licensing. Thus, when internal and final ‘codas’ show similar behaviour, the relevant parameters regarding final empty nuclei have the same settings as those for internal empty nuclei, while in cases where the two positions appear to be different the parameter settings are also different.

The idea of a CVCV pattern has been pursued in a number of studies, and has received various interpretations, some of which are incompatible with each other (Polgárdi (1999, 2003), Rennison (1999b), Rowicka (1999), Szigetvári (1999) among others). In this study, I follow the version of CVCV theory that was developed by Scheer (2000) and Ségéral & Scheer (2001), and presented in Scheer (2004). I present the system in more detail in the following chapter, while examining how the gradual acquisition of consonant clusters in child language can be captured in such a model.

## 6 Conclusion

I presented some of the developments of phonological theory that eventually led to CVCV theory. Syllable-free, rule-based phonology was followed first by a hierarchical view of structure, to return eventually to non-hierarchical representations, which are now controlled by a constrained system of principles and parameters. The field of first language acquisition has followed the advances of phonological theory and examined each new claim using developmental data. However, no acquisition study has been conducted yet within the CVCV framework.

## CHAPTER 2. CLUSTER ACQUISITION IN CVCV

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### 1 Introduction

In this chapter, I present the CVCV theory assumptions for syllable structure and I propose a parametric model of the acquisition of consonant clusters based on these assumptions. The presentation takes the following form: each section deals with a specific type of cluster. In each case, I first present the structure of the cluster according to CVCV theory and then I propose a CVCV theoretic analysis of existing acquisition data, with regard to the cluster at issue. The categorisation of the clusters follows claims of CVCV theory<sup>1</sup>.

Central to the proposed analysis is the notion of markedness. Markedness, in the form of implicational universals in language typology, is encoded in CVCV theory. A major contribution of this thesis is the investigation of markedness relations in acquisition. However, existing acquisition studies provide fragmentary data that do not suffice for a complete investigation of the issue. For this reason, the question will be further explored in the light of a large body of new experimental data, which were collected with this specific issue in mind (chapters 3 and 4).

This chapter proceeds as follows: section 2 deals with word medial clusters of non-rising sonority, while section 3 deals with final consonants. Section 4 discusses clusters of rising sonority and section 5 word final clusters. The special case of word initial clusters of non-rising sonority is reserved for section 6. In section 7, I present some adult language phenomena in support of the proposed

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<sup>1</sup> Note that throughout the chapter I use the term sonority in a descriptive fashion, in order to facilitate the presentation, without attributing any theoretical value to the term.



analysis, and in section 8, I discuss various issues related to the study of language acquisition, including the perception-production problem. A short conclusion follows.

## 2 Clusters of non-rising sonority

### 2.1 The phenomenon

Children at the early stages of acquisition do not produce clusters of non-rising (or falling) sonority. In this section I discuss such word internal clusters: neither word final nor word initial ones, which will be discussed in sections 5 and 6 respectively. Moreover, s+consonant clusters will be examined separately in chapter 4. In the Greek examples that follow in 1 (Tzakosta 1999), the child reduces the cluster to a single consonant, while in 2 (Tzakosta 2003) the child inserts a vowel that breaks up the cluster.

1. a. *'irθe* → *'iθe* 'she came'  
     b. *v'olta* → *v'ota* 'walk, excursion'  
     c. *p'orta* → *p'ota* 'door' (Dionisis 2;01)
2. *aft'o* → *epit'o* 'this' (Bebis 1;11,28)

### 2.2 Empty nuclei

In a system like CVCV, which does not recognise the existence of any branching constituents (Lowenstamm 1996; Scheer 2004), a cluster of non rising sonority would be represented as in 3.

3. Cluster of non rising sonority (version one)

O	N	O	N
C	Ø	T	V

An initial version of the representation of the Greek word *v'olta* in 1b is given in 4 below.

#### 4. Representation of *v<sup>l</sup>olta* (version one)

O N O N O N  
| | | | |  
v o l Ø t a

*volta* 'walk, excursion'

Let us now see how cluster acquisition can be captured in a model with such structures. According to our example in 4, the first member of the cluster can be defined as an onset occurring before an empty nucleus; the *l* is followed by Ø. The output *v<sup>l</sup>olta* in 1b can thus be described as the result of deletion of the consonant before the empty nucleus. Similarly, output *epit<sup>l</sup>o* (for target *apt<sup>l</sup>o*) in 2 can be described as the result of insertion of melodic material in the empty slot. To examine why these processes take place, we need to present some of the principles and mechanisms of CVCV theory.

### 2.3 The Empty Category Principle and government

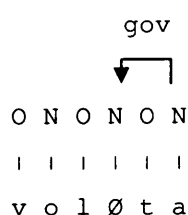
The Empty Category Principle (ECP) is a principle that controls syllabic structure by limiting and regulating the existence of empty nuclei. It was introduced in a somewhat different way, though the same spirit, in Kaye et al. (1990).

#### 5. Empty Category Principle (version one)

An empty nucleus may remain unexpressed iff it is governed.

Government is a syntagmatic internuclear relation. It is always regressive (direction right to left). When a nucleus governs a preceding empty nucleus the governee remains phonetically silent. The complete representation of the word *v<sup>l</sup>olta*, including the syntagmatic relation of government is given in 6. The empty nucleus between the two consonants *l* and *t* is governed by the following nucleus. The unexpressed nucleus is governed, as the ECP requires, and the resulting structure is therefore well-formed.

## 6. Representation of *v<sup>l</sup>olta* (final version)



*v<sup>l</sup>olta* 'walk, excursion'

The ECP is claimed to be a universal principle, while government is assumed to be a universal parameter. Government in CVCV is the evolution of direct government licensing in standard Government Phonology (Charette 1990, 1991). Direct government licensing, just like government, is a regressive force that regulates the existence of clusters of falling sonority. It originates from a nucleus, which gives the power to the less sonorous consonant to control the more sonorous one, in order for the cluster to exist<sup>2</sup>. In standard Government Phonology, government licensing is parameterised in order to capture language typology. The nuclei of languages without clusters of falling sonority have no power to dispense indirect government licensing. Translating this into CVCV terminology, government is controlled by a binary parameter (7): in languages that have a negative setting for the parameter, there are no clusters of falling sonority.

## 7. Nuclei+/-govern

Parameterisation of government has already been proposed in CVCV (Scheer 2004), but for nuclei of other types (final empty nuclei, see section 3, alternating nuclei, see section 7). In this thesis, the already existing parameterisation is extended to cover nuclei with associated melodic material, which I shall be calling full nuclei. In 8, I give the representation of a full nucleus.

<sup>2</sup> The two powers (that is government in CVCV and direct government licensing in standard GP) are not identical. A major difference between the two is that government licensing in standard Government Phonology makes reference to the melodic composition of the segments involved, while government in CVCV is independent of any melodic properties.

## 8. Full nucleus

N  
|  
V

Finally, note that the branching-free structure in CVCV frees us from a redundancy present in the Government Phonology system. In Government Phonology two separate mechanisms are responsible for the same function: a syntagmatic mechanism (government-licensing) and an arboreal mechanism (branching rhymes) both determine the structure of clusters of non-rising sonority. This is reflected in the fact that either of the two mechanisms can be assumed to be parametric: government licensing, as discussed earlier, or the branching rhyme structure, as assumed by Pan (2005) (see chapter 1, section 4.3). Recall that the parameter that regulates clusters of non rising sonority in Pan's system (as well as in Fikkert's model (1994)) is the Branching rhyme parameter. Eliminating the branching structure, as in CVCV, eliminates this redundancy (see also Scheer (2004), Takahashi (1993, 2004)).

## 2.4 Rescuing strategies

Let us imagine what would happen if we tried to accommodate the word *v<sup>l</sup>olta* in a language that has a minus setting for government (Nuclei-govern). As we can see in 9, since nuclei in that language do not have the power to govern, government would not take place. The ECP could not be satisfied, since the empty nucleus would be ungoverned (in bold), and the structure would be ill-formed.

### 9. *v<sup>l</sup>olta* in a language with Nuclei-govern: ill formed

★  
O N O N O N  
| | | | |  
v o l **∅** t a

In such cases, however, the derivation does not necessarily crash: there are strategies that can be employed to rescue the structure. These strategies involve either insertion of melodic material or deletion of the empty nucleus. Evidence for

such strategies can be found in loan word phonology and in native (adult) phonology (see section 7). Attaching melodic material to the nucleus in question rescues the structure by turning the empty nucleus into a full one, which is not subject to the ECP. In our imaginary language, with the Nuclei-govern setting, the word in 9 would surface as *volVta*, where *V* is an epenthesised vowel (for quality of the vowel see section 7).

10. Rescuing strategy a, epenthesis: output *v<sup>l</sup>olVta*

O	N	O	N	O	N
v	o	l	V	t	a

Deletion of the empty nucleus also eliminates the problem. In such case, however, an adjacent onset is deleted along with the nucleus, so that the CVCV (Onset Nucleus Onset Nucleus) pattern is retained (for choice of the consonant to be deleted see footnote 3). In the case of example 9, deletion of the onset hosting *l* would result in output *vota*, as shown in 11 (the brackets indicate deletion).

11. Rescuing strategy b, deletion: output *v<sup>l</sup>ota*

O	N	O	N	O	N
v	o	l	∅	t	a

In both cases the resulting structure contains no ungoverned empty nuclei, and is therefore well formed. To sum up, we have seen how failure to apply government in a structure with an empty nucleus is against the requirements of the ECP, and the resolution of this clash is cluster reduction or vowel epenthesis.

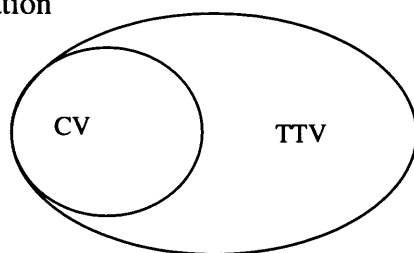
## 2.5 Government and acquisition

I have claimed that a negative setting of the Nuclei+/-govern parameter can result in vowel epenthesis or cluster reduction in adult language. Child language, being a human language, follows the same principles and parameters as adult languages (see section 8). A Nuclei-govern setting will have as a consequence the absence of clusters of non-rising sonority in the child's output. Cluster reduction in child

language is the result of such a setting<sup>3</sup>. The cluster reduction examples given in 1 are results of such a negative setting. Epenthesis is also possible, as seen in 2, although it is not as common as reduction<sup>4</sup>.

I follow here Dresher & Kaye (1990) (see also Dresher (1999, 1990)) in assuming that parameters at the initial state have a default (unmarked) setting, which switches to the marked setting if positive evidence is encountered. This is based on the hypothesis that only positive evidence can be used in acquisition (Chomsky (1986), see also Gibson & Wexler (1994)). In this case, clusters of non-rising sonority are only permitted under the positive setting of the parameter: the forms permitted under the negative setting of the parameter are a proper subset of those allowed under the positive setting<sup>5</sup>.

## 12. A subset relation



Small oval: forms under Nuclei-govern

Large oval: forms under Nuclei+govern

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<sup>3</sup> The choice of consonant that is deleted in cluster reduction has been the subject of extensive study (e.g. Chin (1996), Fikkert (1994), Gnanadesikan (2004), Ohala (1999), Pater & Barlow (2003), among many others). The standard analysis is that the choice of consonant is determined by sonority: the more sonorous consonant is deleted, the less sonorous consonant remains (see e.g. Gnanadesikan (2004), Ohala (1999), Pater & Barlow (2003)). In recent studies (Goad & Rose (2003), Jongstra (2003)), it is argued that structural relationships such as headedness also play a role in the process. Important evidence supporting such an analysis come from variation in cluster reduction: the sonority pattern mentioned above is not always followed. More recently, Pan (2005), in the spirit of Government Phonology, analyses cluster reduction using complexity.

<sup>4</sup> For a tentative suggestion on the reasons for this imbalance, see section 7.1.

<sup>5</sup> Note that this type of subset relation is normally not found in the parameters controlling metrical systems (Dresher & Kaye 1990). The task of the linguist studying the parameters of metrical systems is thus considerably harder.

We can therefore determine that the marked setting is the positive one (Nuclei+govern). The existence of the cluster will constitute the cue (trigger) for a change of value.

Crosslinguistic data support the analysis of the positive setting as marked: the existence of clusters of non-rising sonority in a language implies the existence of clusterless (CV) sequences, while the opposite is not true (i.e. languages with CV sequences may or may not have clusters of non-rising sonority). And, finally, empirical evidence from acquisition studies is in accordance with the analysis: children initially produce only CV sequences, while clusters of non rising sonority are added to their repertoire later.<sup>6</sup>

To sum up, I have argued that the absence of clusters of non-rising sonority in early child language is due to a (default) negative setting of the Nuclei+/-govern parameter.

### 3 Word final single consonants

#### 3.1 The phenomenon

In this section I discuss the acquisition of word final single consonants. Children at the early stages of acquisition typically omit word final consonants (Fee 1995; Fikkert 1994). The examples in 13 (Kappa 2002) come from a child acquiring Greek.

#### 13. Deletion

a. *fos* → *fo* ‘light’ (Sofia 2;0)

b. *bes* → *be* ‘enter’ IMP.2<sup>ND</sup> SG (Sofia 2;07)

Moreover, cases of children that insert a vowel after the final consonant have been reported (Demuth & Kehoe 2006; Goad 1998). The following examples (Demuth & Kehoe (2006)) come from children acquiring (European) French.

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<sup>6</sup> It is important that government does not control only the existence of clusters of non-rising sonority. Combined with licensing (see section 5), they regulate, amongst other things, consonantal alternations (lenition and fortition phenomena), vowel length and vowel zero alternations (Scheer 2004). This way, we should be able to discover in acquisition situations where the change of a parameter setting causes several phenomena to appear at once. This is a hypothesis for future research.

#### 14. Epenthesis

- a. vague *vag* → *bagə* ‘wave’ (Ag 2;01,08)
- b. machine *mafin* → *mafinə* ‘machine’ (Ag 2;01,22)
- c. cube *kyb* → *kybə* ‘block’ (Ar 2;06,11)

### 3.2 Word final empty nuclei

What is relevant to the analysis of these phenomena is the word final empty nucleus. In CVCV, just like Government Phonology (chapter 1, section 4.2), word final consonants are followed by an empty nucleus (see Kaye (1990) for Government Phonology, Scheer (2004) for CVCV).

#### 15. Word final empty nucleus

O N (#)  
I I  
C Ø

To regulate the existence of word final empty nuclei, Kaye (1990) introduces a binary parameter that determines whether word<sup>7</sup> final empty nuclei are allowed in a language or not (16).

#### 16. Parameter

Final empty nuclei: +/- governed<sup>8</sup>

The parameter covers cross-language variation in word final single consonants. Languages that allow word final consonants have a positive setting for the parameter, as seen schematically in 17 and with an example from Greek in 18 below. The final empty nucleus is governed, and the ECP (section 2.3) is thus satisfied.

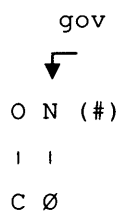
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<sup>7</sup> Kaye discusses domain final, rather than word final empty nuclei, in order to account for morphological operations. However, for our purposes, and since our discussion does not involve morphology, the term word final is appropriate.

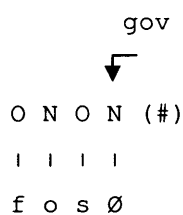
<sup>8</sup> Kaye's terminology is licensing, and not government. I follow Scheer (2004) in using the term government instead, as a term for a force that inhibits the melodic expression of its target, and reserve the term licensing for different functions (see section 4.2).



### 17. Government of word final empty nuclei



### 18. Government of word final empty nuclei in Greek



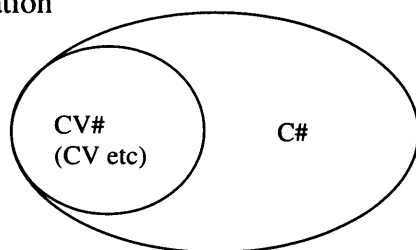
*fos* 'light'

Languages with a negative setting for this parameter disallow word final consonants.

## 3.3 Final empty nuclei and acquisition

With the Final empty nuclei+/-governed parameter, the forms permitted under the negative setting are a proper subset of the forms permitted under the positive setting. Note that this relation is identical to the one we saw in 12 with regard to the Nuclei+/-govern parameter.

### 19. A subset relation



Small oval: forms under Final empty nuclei-governed

Large oval: forms under Final empty nuclei+governed

We can therefore determine that the marked setting of the parameter is the positive one. The Final empty nuclei +/- governed parameter is initially set to minus; children start with a grammar that does not involve government of final empty nuclei. As a

result, words with final consonants would be ill-formed in their grammar. In 20, I give the representation of the Greek word *fos* in a (child) language that has a negative setting for this parameter. The structure does not satisfy the ECP, since it contains an empty nucleus that is not governed.

20. *fos* in a language with Final empty nuclei-governed: ill formed

O	N	O	N	(#)
f	o	s	Ø	

Children need to switch to the positive value in order to secure word-final consonants. Note that a parametric account of the acquisition of final empty nuclei has been proposed in standard Government Phonology (Pan 2005, Pan & Snyder 2003, 2005), as discussed in chapter 1, section 4.3. However, the formulation of the parameter proposed in these studies (Final empty nuclei Yes/No) fails to establish any connection to the ECP, which, in Government Phonology (like CVCV) is the principle that regulates the existence of empty nuclei. If the parameter refers to government of empty nuclei, which is the formulation adopted here, then it becomes part of the wider family of parameters (including the Nuclei+/-govern discussed in the previous section) that answer to the ECP.

At the initial stages of acquisition, children have two strategies to chose from in order to rescue the structure; either deletion of the empty nucleus and the final consonant (examples in 13), or vowel epenthesis in the empty nucleus slot (examples in 14). Several researchers ((Goad 1998; Goad & Brannen 2000; Pan 2005; Pan & Snyder 2003, 2004; Rose 2000) use the existence of the latter strategy as an argument for an onset analysis of word final consonants, as opposed to a coda analysis (e.g. Fikkert (1994)). Note, however, that of these studies, Pan & Snyder (2003, 2004) and Pan (2005) interpret these data as part of the evidence for a universal syllabification of final consonants as onsets. Most of these studies assume that this syllabification is followed by the child, while in adult languages word final consonants may be codas.

To sum up, I have argued that the fate of word final consonants in child language can be analysed with the aid of a binary parameter regarding final empty nuclei, in conjunction with the ECP.

## 4 Clusters of rising sonority

### 4.1 The phenomenon

The acquisition of clusters of rising sonority (TR) has been the main focus of previous research on the acquisition of consonant clusters (e.g. Barlow (1997), Gierut (1999), Pater and Barlow (2003), Smit (1993)). Children at the early stages of acquisition do not produce such clusters. The examples that follow come from children acquiring Greek.

#### 21. Deletion (Tzakosta 2001)

- a. *k<sup>l</sup>ukla* → *k<sup>l</sup>uka* ‘doll’ (Dionisis 2;01,23)
- b. *k<sup>l</sup>itrina* → *k<sup>l</sup>itina* ‘yellow’ N.PL (Dionisis 2;01,16)
- c. *ɣr<sup>l</sup>afo* → *ɣ<sup>l</sup>afo* ‘write’ 1<sup>ST</sup> SG (Dionisis 2;01)
- d. *xr<sup>l</sup>oma* → *x<sup>l</sup>oma* ‘colour’ (Dionisis 2;01)

#### 22. Epenthesis (Kappa 2002)

- a. *ble* → *bel<sup>l</sup>e* ‘blue’ (Sofia 2;02)
- b. *bl<sup>l</sup>uza* → *bel<sup>l</sup>ula* ‘blouse’ (Sofia 2;05)

### 4.2 Licensing

In traditional models of syllable structure, such clusters constitute complex onsets. The relevant parameter that has been proposed is the Branching onset parameter, by Fikkert (1994), as well as by Pan (2005) in Government Phonology. In CVCV, however, there are no branching structures. Any consonant cluster will involve an empty nucleus. A (partial) representation of the Greek word in 21b is thus as follows.

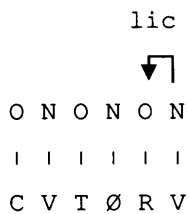
#### 23. Representation of *k<sup>l</sup>itrina* (version one)

○	N	○	N	○	N	○	N
k	i	t	∅	r	i	n	a

Although such a structure appears to be identical to the structure of clusters of non-rising sonority discussed in section 2, the difference between ‘coda-onsets’ and

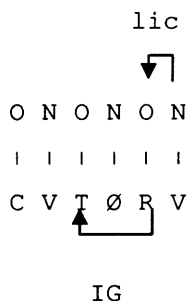
‘branching onsets’ is captured in CVCV by the application of different parameters. Scheer (1999) presents a theory of consonantal interaction, according to which the condition necessary for the establishment of a domain containing consonants of rising sonority is not government but licensing. In order for the cluster to exist, the following nucleus must license the sonorant<sup>9</sup>, as shown in 24 below.

#### 24. Licensing



Once the sonorant is licensed, it can dispense infrasegmental government to the preceding consonant. The functions of licensing and infrasegmental government are given schematically in 25.

#### 25. Licensing and infrasegmental government



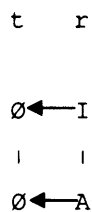
According to Scheer’s (2004) definition of infrasegmental government, a consonant A may contract a governing relation with a preceding consonant B iff there is a place-defining autosegmental line where A possesses a prime (or element, see chapter 1, section 4.1), while the corresponding slot in the internal structure of B is

<sup>9</sup> The idea that an (onset) cluster must be licensed by its nucleus was developed in Government Phonology by Charette (1991). The main difference between the Government Phonology and the CVCV theoretic view of these clusters is that in Government Phonology the obstruent is the head of the cluster, while in CVCV theory it is the sonorant that receives licensing by the nucleus for the establishment of the domain.

empty. When this situation obtains, the prime belonging to A governs the empty position of B.

I illustrate this with the TR cluster of the Greek word we have been using – *k'itrina*. According to Scheer (2004, based on Scheer (1996, 1999)), the first member of the *tr* cluster (*t*) contains no place elements<sup>10</sup>, while the second (*r*) contains two (I and A). The two elements of the latter consonant can govern the empty place slots of *t*.

## 26. *tr* cluster: infrasegmental government



The existence of the infrasegmental relation between the two consonants has the ability to satisfy the ECP concerning the empty nucleus in between.

## 27. Empty Category Principle (final version)

A nucleus may remain unexpressed iff

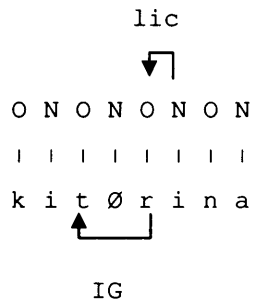
- a) it is governed, or
- b) it is enclosed within a domain of infrasegmental government

Before examining the role of licensing in acquisition, I give the representation of the Greek word *k'itrina* with all the relevant syntagmatic relations.

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<sup>10</sup> Scheer argues that coronals are underspecified for place; no place-defining element contributes to their articulation.

## 28. Representation of *k<sup>l</sup>itrina* (final version)



### 4.3 Licensing and acquisition

In the same spirit as our discussion on government (see section 2), I propose that licensing is controlled by a binary parameter equivalent to the Branching rhyme parameter (Fikkert 1994; Pan 2005). In languages where full nuclei have the ability to license, TR clusters are permitted, while these clusters are disallowed in languages where full nuclei cannot license (see Cyran (2003) for a similar proposal, involving strength scales for nuclei). The parameter is given in 29.

## 29. Parameter: Nuclei +/-license

Note that infrasegmental government is an automatic mechanism, in the sense that it occurs whenever licensing takes place. There is no parameter that controls infrasegmental government. In languages that do not have licensing, this mechanism is simply never activated during the acquisition process.

The absence of TR clusters at the early acquisition stages is caused once again by a negative setting of the parameter, along with the ECP. When the child still has the initial negative setting for the licensing parameter, infrasegmental government does not take place and the ECP dictates that the structure is ill-formed. Example 30 shows the representation of the Greek word *k<sup>l</sup>itrina* in a grammar that has a negative setting, along with the rescuing strategy of deletion, resulting in the output *k<sup>l</sup>itina* (see example 21b).

### 30. Deletion: output *k'itina*

o	n	o	<span style="border: 1px solid black; padding: 0 2px;">n</span>	<span style="border: 1px solid black; padding: 0 2px;">o</span>	n	o	n
k	i	t	∅	r	i	n	a

Epenthesis is another possible strategy, which consists in the insertion of melodic material into the empty nucleus slot. In addition to the Greek examples in 21, I present here some further examples from a child acquiring English (Barlow 1997).

### 31. Epenthesis

- a. grow    *grəʊ* → *gərou*
- b. play    *pleɪ* → *pəleɪ*
- c. blowing    *bləʊwɪŋ* → *bəlouwɪŋ* (subject 12V, 3;10)

In this section, I argued that the licensing parameter controls the acquisition of clusters of rising sonority.

## 5 Word final clusters

### 5.1 The phenomenon

At the early stages of language acquisition, children do not produce word final clusters (Fikkert (1994), Kirk & Demuth (2003)). The examples of final cluster reduction in 32 come from the production of Smith's (1973) son Amahl, and the examples of epenthesis in 33 from children acquiring (European) French<sup>11</sup> (Demuth & Kehoe 2006).

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<sup>11</sup> Note that schwa epenthesis sometimes occurs in adult French (an indication that schwa in French is underlyingly present (see section 7.2)). The difference between child and adult French with respect to final schwa epenthesis is thus quantitative rather than qualitative.

### 32. Deletion

- a. frost *frɒst* → *fɹɔt*
- b. help *help* → *ɛp*
- c. ask *a:sk* → *a:k*
- d. fact *fækt* → *wæt*

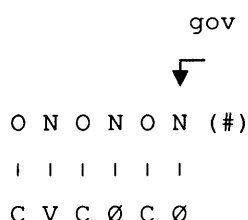
### 33. Epenthesis

- a. sable *sabl* → *sablə* ‘sand’ (Ag 2;01,22)
- b. table *tabl* → *tablə* ‘table’ (Ag, 2;01,22)
- c. livre *livʁ* → *libʁə* ‘book’ (Ar, 2;06,11)

## 5.2 Final empty nuclei: government and licensing

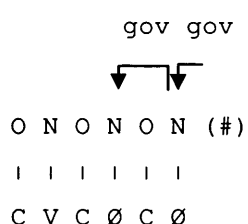
Since syllable structure in CVCV is a sequence of onsets and nuclei, the representation of a word final cluster involves two empty nuclei, as shown in 34.

### 34. Word final cluster (version one)



As far as the final empty nucleus is concerned, the ECP is satisfied by government, assuming that the setting for that parameter is positive. There is a second empty nucleus, before that, and that would have to be governed by the final empty nucleus, in order for the ECP to be satisfied. The full representation of the cluster would thus be as follows.

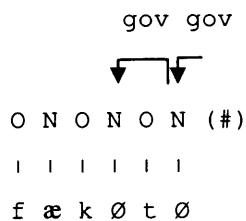
### 35. Word final cluster (final version)





As an example, I give under 36 the full representation of the English word *fækt* ‘fact’.

### 36. Representation of *fækt*



*fækt*

The source of government here is different from the sources we have seen so far; it is a final empty nucleus that governs. From the early days of Government Phonology it has been convincingly argued that final empty nuclei can have syntagmatic powers (Charette 1991). Scheer (2004) demonstrates how government coming from final empty nuclei can account, amongst other things, for word final clusters. Moreover, syntagmatic powers of final empty nuclei are parameterised. The relevant parameter is given below.

### 37. Parameter

Final empty nuclei+/-govern<sup>12</sup>

Languages with word final clusters, for example English, French and German, have a positive setting for this parameter. In contrast, languages that have no word final clusters have a negative setting.

However, word final clusters of rising sonority and falling sonority do not behave in the same way. For example, obstruent-liquid clusters in Quebec French

<sup>12</sup> A terminological clarification concerning the parameters for empty nuclei: the parameter in 16, that is Empty nuclei+/-governed, and the one in 37, Empty nuclei+/-govern, are of a similar nature (they both involve government), but their function is different. The former determines whether the final empty nucleus is governed or not, and thus if the language permits word final single consonants, while the latter controls whether the (governed) final empty nucleus has governing powers, and therefore determines the existence of word final clusters in the language.

have been argued to pattern differently from other final clusters (Charette 1991). One process found in this language involves vowel lengthening or vowel diphthongisation in open syllables (syllables that do not contain a coda consonant 38a) but not in closed syllables (38b). In word final contexts, the process can apply to vowels before singleton consonants (38c) or obstruent-liquid clusters (38d) but not before liquid-obstruent clusters (38e).

### 38. Vowel lengthening/diphthongisation in Quebec French

a. rêver		<i>ʁɛ:v / ʁaiv</i>	‘(to)dream’
b. perdu	<i>peʁdy</i>	<i>*peʁdy / *paivdy</i>	‘lost’
c. rêve		<i>ʁɛ:v / ʁaiv</i>	‘dream’
d. sable		<i>sa:bl / sa<sup>u</sup>bl</i>	‘sand’
e. forte	<i>fɔʁt</i>	<i>*fɔ:ʁt</i>	‘strong’

Charette (1991) uses this evidence for an analysis where final liquid-obstruent clusters consist of a coda and an onset (followed by an empty nucleus) while obstruent-liquid clusters form branching onsets (again followed by an empty nucleus).

In CVCV terms this means that, in Quebec French, obstruent-liquid clusters are dependent on licensing by the final empty nucleus, while liquid-obstruent clusters are formed by government, as discussed earlier. We can thus add one more parameter to our inventory, namely one that controls word final obstruent-liquid clusters.

### 39. Final empty nuclei+/-license

The binary parameter has been proposed in CVCV (Scheer 2004) based on segmental effects (see footnote 6 and section 6.2). However, its role in cluster formation has not, to my knowledge, been previously discussed.

## 5.3 Government from final empty nuclei and acquisition

I propose that the acquisition of word final clusters is dependent on the settings of the two parameters: Final empty nuclei+/-license and Final empty nuclei+/-govern.

The former controls obstruent-liquid clusters, while the latter controls the rest of the clusters. The unmarked (initial setting) of each of these parameters is minus (since the minus setting allows a proper subset of the forms allowed under the plus value) and this is responsible for the absence of word final clusters in early child language.

Note that a positive setting of the Final empty nuclei+/-governed parameter is necessary for a positive setting of the Final empty nuclei+/-govern parameter. In order for a single word final consonant to exist, final empty nuclei must be +governed. If a final empty nucleus is not governed it cannot exist, as we saw in section 3, and an object that does not exist cannot have any powers. This ordering in the setting of the parameters, enforced by theory-internal reasons, has as implication that word final clusters are expected to be acquired after word final singletons, which is what acquisition data show (see, e.g. Levelt, Schiller, & Levelt (2000)).

Having introduced a number of different parameters, we can start investigating possible relationships between them, as well as examining any predictions following from the analysis. For example, one prediction made by the analysis is that final obstruent-liquid clusters are expected to be acquired separately from other final clusters. This follows from the assumption that the two are controlled by independent parameters: the former by licensing, the latter by government. Moreover, the relationship and possible implications in the setting of parameters regarding full nuclei (Nuclei+/-govern, Nuclei+/-license) and those regarding final empty nuclei (Final empty nuclei+/-govern, Final empty nuclei+/-license) could be examined. These can be tested by examining the production of children acquiring a language that contains all the different cluster types controlled by the above parameters. However, I will not pursue this here<sup>13</sup>. The existing acquisition studies are not very illuminating in this area, mainly because of the different theoretical assumptions of other researchers. For example, Levelt, Schiller & Levelt (2000) compare the acquisition of CVCC and CCVC ‘syllables’ in Dutch, where CC stands for any cluster, without distinguishing between different cluster types.

Careful experimentation will allow us to compare CVCV acquisition with the predictions made by other models. An example of a prediction that differs from that made by Pan’s (2005) model regards the acquisition of medial codas and final

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<sup>13</sup> See Seigneur-Froli & Sanoudaki (in preparation) for experimental work aimed at examining this.

clusters. Pan's (2005) study makes the prediction that word medial codas and word final clusters should be acquired simultaneously, while the CVCV parametric model developed here predicts no fixed ordering in their acquisition.

Pan develops an acquisition model within Government Phonology, which uses the Branching rhyme parameter to capture the acquisition of final consonant clusters. Following the Government Phonology analysis that final clusters involve a branching rhyme plus an onset, Pan sets a marked value of the Branching rhyme parameter as a necessary and sufficient requirement for the existence of final clusters. Moreover, word medial 'codas' (preobstruent consonants) in Government Phonology are also analysed as branching rhymes, and are thus also controlled by the same (Branching rhyme) parameter. Consequently, word medial codas and word final clusters have the same (necessary and sufficient) requirements and are therefore expected to be acquired simultaneously<sup>14</sup>.

In contrast, the CVCV model presented here assumes that the necessary and sufficient requirements for the two cluster types form two independent sets. Word medial clusters of non rising sonority (word medial codas) require a Nuclei+govern setting, while word final clusters require a Final empty nucleus+govern and Final empty nuclei +governed settings for their existence. Consequently, no fixed ordering in the acquisition of the two structures is expected.

Pan's prediction does not seem to be supported by the acquisition data. Although Rose (2003) reports on a child that acquired word medial codas and word final clusters simultaneously, a pattern consistent with Pan's analysis, in Fikkert's (1994) study, children do not acquire word medial codas and word final clusters simultaneously (40-41).

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<sup>14</sup> Pan's analysis assumes that a marked setting of the Branching rhyme parameter in fact implies a marked setting of the (final) Empty nucleus parameter and therefore as soon as the Branching rhyme parameter is set to Yes, the (final) Empty nucleus parameter will automatically follow.

Note that this position is not tenable, given that in the framework in which she is working it is accepted that word medial RT clusters require a marked setting of the Branching rhyme parameter, independently of the setting of the (final) Empty nucleus parameter. Crucially, Pan's analysis fails to allow for this parametric option.

40. Elke: acquiring medial codas before final clusters

a. medial codas

*elkə* → *alkə* (2;02,06)

b. final clusters

*εχt* → *aχ* 'really' (2;02,06)

*kast* → *kast* 'cupboard' (2;03,27)

41. Robin: acquiring final clusters before medial codas

a. final clusters

*dɪχt* → *tɪχt* 'closed' (2;0,18)

*fe:st* → *fɪst* 'party' (2;0,18)

b. medial codas

*tr<sup>h</sup>ektər* → *t<sup>h</sup>aka* 'tractor' (1;10,07)

*d<sup>h</sup>ɔktər* → *d<sup>h</sup>ɔktəɹ* 'doctor' (2;01,07)

Elke started producing medial codas when she could not produce any final clusters, at 2;02.06 (40a). Fikkert reports that Elke's production of final clusters started at a later stage (40b). Robin's data (41) show the opposite pattern: final clusters appear at a stage when no medial codas are produced. Both Elke's and Robin's patterns are inconsistent with Pan's analysis.

What these two children's data seem to show is that the acquisition of medial clusters of non-rising sonority is independent of the acquisition of word final clusters. This is what we would expect following the CVCV model.

It has recently been argued (Cyrano 2003) that final empty nuclei cannot have higher syntagmatic powers than full nuclei. If, in a given grammar, full nuclei can govern, then final empty nuclei may or may not be able to govern, but the reverse is not true: if full nuclei cannot govern, then final empty nuclei cannot govern either. This creates a strength scale involving full nuclei, alternating ones (on which see section 7) and final empty nuclei, in descending order of strength. The implication for acquisition is that final clusters are expected to be acquired no sooner than (simultaneously with or later than) word medial clusters of non-rising sonority. Robin's data in 41 point against such an analysis.

However, findings of recent research on the acquisition of (European) French clusters (Demuth & Kehoe 2006) are consistent with the view that final empty nuclei are less powerful than full nuclei. Demuth & Kehoe tested the acquisition of obstruent-liquid clusters in word initial versus word final position and found that these clusters were consistently acquired in word initial position first. In CVCV terms, this means that French children switch to the marked setting of the Nuclei+/-license parameter before switching to the marked setting of the Final empty nuclei+/-license parameter. The opposite order in parameter switching was not attested (i.e. marked setting for the Final empty nuclei+/-license parameter with an unmarked setting for the Nuclei+/-license parameter). Further research is required in this domain, involving the testing of the relevant cluster types in different languages.

## 6 Word initial clusters of non rising sonority

### 6.1 The phenomenon

In CVCV, word initial clusters of non-rising sonority (TT) constitute a separate category. Such clusters have been neglected in the acquisition literature, possibly because they do not exist in English. The only clusters of this type that English possesses are s+consonant clusters, the development of which has been examined in several developmental studies (e.g. Barlow (2001), Gierut (1999), Smit (1993)). sC clusters will be discussed in chapter 4.

In this section, I discuss the acquisition of other consonantal sequences that do not have a rising sonority, such as *xt*, *ft*, *ɣð*, *vð* etc. that can be found in Greek. The Greek examples that follow indicate that such clusters are not produced at the early stages of acquisition.

42. a. *xtipame* → *tibame* ‘we hit’ (Dionisis 2;07,06) (Tzakosta 2003)

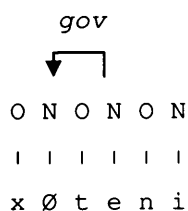
b. *ftani* → *tani* ‘it's enough’ (Sofia 2;04,18)

c. *xteni* → *teni* ‘comb’ (Sofia 2;04,18) (Kappa 2002)

### 6.2 Word initial ON

The structure of a word with a word initial TT cluster in CVCV, for example the Greek word *xteni* ‘comb’, is the following.

### 43. Representation of *xteni*



The cluster is not a TR cluster, so it is government, and not licensing, that is required for satisfaction of the ECP.

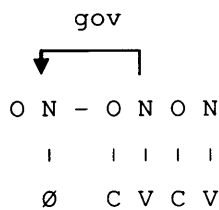
If the ability of full nuclei to govern were a sufficient requirement for the existence of such clusters, CVCV theory would make an unfortunate typological prediction. According to the principles we have so far introduced, the prediction would be that in any language where full nuclei have the ability to govern – that is in any language that has word internal clusters of non-rising sonority – there should exist such word initial clusters, as well. However, this is not true. In several Indo-European languages, for example English, French and German, TT clusters are banned at the beginning of the word, even if they exist word internally. This distribution is considered to be more widespread, in contrast with the more ‘exotic’ pattern that allows TT clusters in word initial position. This pattern is represented in Indo-European by Polish, Czech and Greek, for example and outside Indo-European by Moroccan Arabic and Berber, for example. In order to account for this difference, we shall introduce one last element of CVCV theory, namely word initial ON.

Lowenstamm (1999), in his analysis of the definite article in Classical Hebrew, proposed that the left margin of the word is an onset nucleus pair without any segmental content. In so doing, he replaced the object # with a familiar phonological object: #ONON is now ON-ONON<sup>15</sup> (the hyphen has no theoretical status, it is just for expository reasons).

<sup>15</sup> Onsets and nuclei are objects whose properties can be examined in a variety of (other) contexts.

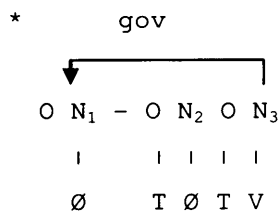
Crucially, the initial empty nucleus, like any empty nucleus, must be governed<sup>16</sup>. Thus the first full nucleus will be asked to govern the initial empty one, as sketched out in 44 below.

#### 44. Government of the initial empty nucleus



Scheer (2000a), argues that the existence of the initial ON is parameterised (binary parameter on/off). According to Scheer, the initial ON pair exists in languages that have a ban on consonant clusters of non rising sonority in word initial position.

#### 45. #TT clusters in a language with initial ON: ill-formed



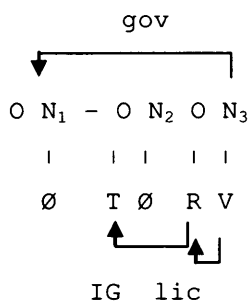
As shown in 45, the initial empty nucleus, N<sub>1</sub>, requires government in order for the ECP to be satisfied. Thus it will be the target of the governing power of the full nucleus N<sub>3</sub>. Consequently, N<sub>2</sub> will remain ungoverned and the structure will be ill-formed. This is why such clusters are impossible in languages like English, French and German.

Notice that the existence of an initial ON does not render initial TR clusters impossible. Provided that in the language in question full nuclei have the ability to both govern and license, the relevant structure would be as follows.

<sup>16</sup> Alternative ways of satisfaction of the ECP (27b) are impossible in this case, because domain of infrasegmental government can be established since it would require – among other things – the existence of consonants at both sides of the nucleus.



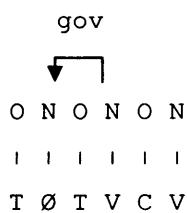
46. #TR clusters in a language with word initial ON: allowed



In 46, the ECP is satisfied, since  $N_1$  is governed and  $N_2$  is enclosed within a domain of infrasegmental government created by licensing.

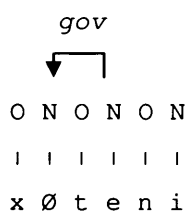
In contrast, languages that allow word initial clusters of non rising sonority do not have a word initial ON.

47. #TT clusters in a language without initial ON: allowed



In 47, there being no initial ON and therefore no word initial empty nucleus, the governing power of the first full nucleus can be directed towards the empty nucleus inside the cluster. The representation in 47 constitutes an abstract partial representation of a word like that of example 43, the Greek word *xteni*, repeated here for convenience.

48. Representation of *xteni*



*xteni* 'comb'

The existence or not of an initial ON addresses the problem mentioned at the beginning of the section. The existence of word internal clusters of non-rising sonority (in other words a positive setting of the Nuclei+/-govern parameter) is a necessary but not a sufficient condition for the existence of such clusters at the beginning of the word. There is another condition on this, namely the absence of an initial ON.

The structure proposed in CVCV for word initial clusters of non rising sonority finds independent support in diachronic lenition and fortition phenomena (Seigneur-Froli 2003, 2004, 2006). For instance, in Greek, the first member of obstruent-obstruent clusters in word initial position behaves like the first member of such clusters in word internal position. An example of this is a diachronic lenition whereby the first member of clusters of two voiceless stops in both word initial and word medial position underwent frication (e.g. *ptero* > *ftero* ‘wing’, *epta* > *efta* ‘seven’). In CVCV, such identical behaviour of the two consonants is expected, since the two consonants are in identical positions: before a governed empty nucleus (49a-b, relevant positions in bold).

#### 49. Before a governed empty nucleus



These positions are structurally identical in the sense that they are targeted by the same amount of syntagmatic forces (in this case neither government nor licensing. This will be discussed in more detail in chapter 5, where the segmental effects of government and licensing (Ségéral & Scheer 2001) will be discussed.

This presents an advantage for CVCV as compared to other syllable-based accounts, which face difficulties in trying to explain such identical behaviour. A well-known analysis of word initial clusters of non-rising sonority is that the first consonant is extrasyllabic (see e.g. Steriade (1982)). As Seigneur-Froli (2006) argues, the lenition effect just described cannot be satisfactorily explained in such an approach: the two consonants in question are different; one is extrasyllabic, while the

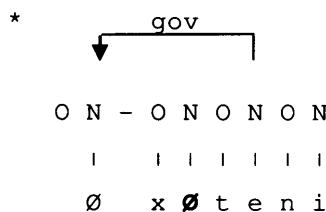
other is a coda consonant. The extrasyllabicity model will be discussed in chapter 4, where I compare the predictions extrasyllabicity and CVCV make with regard to cluster acquisition.

The proposal that the Greek word initial obstruent clusters are separated by an empty nucleus was made before the advancements of CVCV theory, in the Government Phonology framework by Pagoni (Pagoni 1993; Pagoni-Tetlow 1998) (see Seigneur-Froli (2006) for a detailed critique of Pagoni's analysis). A different Government Phonology proposal, which assumes a coda representation for the first consonant of the cluster, will be discussed in chapters 3 and 4.

### 6.3 Word initial ON and acquisition

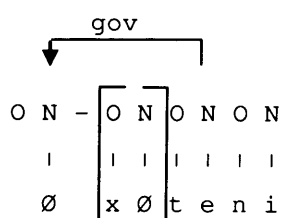
The existence of the word initial ON is regulated by a binary parameter (Scheer 2000a): Initial ON Yes/No. The following example shows the word *xt<sup>l</sup>eni* in a grammar with an initial ON.

50. *xt<sup>l</sup>eni* in a language with initial ON: ill-formed



In 50 there is an empty nucleus that is not governed (in bold), and therefore the ECP is not satisfied. However, the ill-formed structure can be rescued. Under 51 there is a possible rescuing strategy, deletion of the empty nucleus and its onset, giving the output *t<sup>l</sup>eni*.

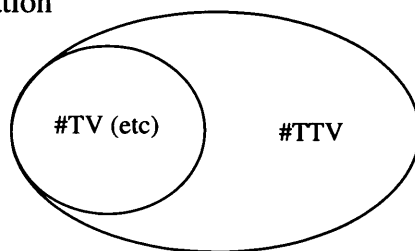
51. Rescuing strategy: output *t<sup>l</sup>eni*



I propose that the unmarked parameter setting for the Initial ON is the Yes value. The existence of this ON is responsible for the absence of word initial clusters of non-rising sonority in early child language. These clusters will appear when the setting of the parameter switches to the No value.

The choice of the unmarked setting is based on the fact that the set of possible forms in grammars with an initial ON is a proper subset of the possible forms in languages without an initial ON.

#### 52. A subset relation



Small oval: forms under Initial ON Yes

Large oval: forms under Initial ON No

As with other parameters, the unmarked state cannot be the grammar producing the superset of forms, because the move to the subset grammar would require negative evidence. In the absence of negative evidence in acquisition, we have to posit the subset grammar, the one with an initial ON, as the unmarked state.

However, such a decision faces a potential problem, regarding languages that have no clusters at all. Such languages have a negative setting for the Nuclei+/- govern parameter, which bans word internal TT clusters, as discussed in section 2. At the same time, this parameter setting makes the existence of an initial ON pair impossible, since government of the empty Nucleus of the ON pair would not take place. Such reasoning is followed by Kula (2006) and Kula & Marten (2006), who conclude that clusterless languages have no initial ON.

We are thus presented with a paradoxical situation, with regard to the values of the initial ON parameter. We have identified three language types of increasing degrees of complexity (in terms of TT clusters) and have assigned a No setting to the least and most complex of them (languages without TT and languages with internal and initial TT), and a Yes setting to the middle one (languages with internal TT clusters only).

### 53. A paradox

Setting of the ON Parameter	TT clusters in the language
No	—
Yes	Internal TT only
No	Internal TT and initial TT

This typologically paradoxical situation makes it difficult for the linguist to decide on the unmarked setting of the ON parameter. Moreover, it presents a problem for first language acquisition. We are forced to say that the parameter starts with a No setting, at the initial state, and when the child encounters word internal TT clusters the parameter switches to Yes, and goes back to No when word initial TT clusters are encountered. Such a switching back and forth of a binary parameter would make the acquisition process non-deterministic: in deterministic learning models, a change from the unmarked to the marked value is possible, but a change from marked to unmarked is interdicted. The situation in 53 might have the unfortunate consequence of forcing us to subscribe to a non-deterministic model, which allows switching back and forth of a parameter despite advantages of the more constrained nature of deterministic acquisition models (Berwick 1985; Marcus 1980).

However, the violation of determinism is only apparent. Having argued that the trigger for a change from Yes to No of the ON parameter is the existence of word initial TT clusters, we established the Yes value as unmarked. This value only becomes available when the Nuclei+/-govern parameter gets fixed at the plus value. When the Nuclei+/-govern parameter is set at the minus value, the Initial ON parameter must be set to No. This (Nuclei-govern, Initial ON No) is the initial configuration of the parameter set. The initial ON No setting is required by Universal grammar at the initial state. The difference between the marked and unmarked settings can be seen when the Nuclei+/-govern parameter switches to plus. As soon as this change takes place, the Initial ON parameter goes back to Yes, which is the unmarked setting, and a change to the marked No setting will take place if the appropriate evidence of initial TT clusters is encountered (see Dresher & Kaye (1990) for a discussion of a similar case regarding metrical structure).

In this section, I examined the acquisition of word initial clusters of non-rising sonority. These clusters will be discussed in more detail in chapter 3, where, using experimental evidence, I test predictions of the CVCV parametric model regarding the acquisition of different cluster types.

## 7 The case of adult grammar

### 7.0

In section 2 I claimed that deletion and epenthesis can be demanded by the ECP in adult language as well. Structures that would be illegal under the parameter setting of the language can be rescued with the application of either of the two strategies. In this section I present two such cases. The first comes from loanword phonology.

### 7.1 Loanword phonology

Vowel epenthesis and consonant deletion are common processes in loanword adaptation<sup>17</sup>. The examples in 54 (from Uffmann (1999)) involve vowel epenthesis, while those in 55 (from Yip (2002)) consonant deletion.

54. Epenthesis

Yoruba	<i>kílààsi</i>	‘class’	
	<i>sùkùrù</i>	‘school’	
	<i>térelà</i>	‘trailer’	(Akinlabi 1993)
Japanese	<i>sutoraiku</i>	‘strike’	(Park 1987)
	<i>fesutibaru</i>	‘festival’	(Itô & Mester 1995)
Setswana	<i>kirimasi</i>	‘Christmas’	

<sup>17</sup> There is a distinction sometimes made in the literature on loanword phonology (see, for instance, Peperkamp (2007)): on the one had, ‘on-line adaptations’ are those that are being performed here-and-now. On the other hand there are words that have entered the lexicon of the borrowing language, and monolingual speakers do not (need to) know their source forms. These are the ‘integrated loanwords’, the study of which receives a diachronic interpretation, in the sense that it reconstructs the adaptations performed by the speakers who first introduced the loanwords. In both cases the processes discussed in this section reflect a psychological reality: that of the speakers who introduce(d) the loanwords.

<i>gelase</i>	‘glass’	
<i>hafu</i>	‘half’	(Batibo 1995)

#### 55. Consonant deletion

Taiwanese Mandarin	<i>t<sup>h</sup>jetani</i>	‘Titanic’	
	<i>ajtita</i>	‘Adidas’	
	<i>pi</i>	‘Burt (Reynolds)’	
	<i>nalat<sup>h</sup>inwowa</i>	‘Navratilova’	
	<i>fuliman</i>	‘Friedman’	(Lin 1998)

These types of adaptation are similar, often identical, to children’s adaptation of adult words. To facilitate comparison, I present side by side some strikingly similar child language data and loanword data.

#### 56.

Child language	Loanword adaptation
a. Epenthesis	
<i>bl’uza</i> → <i>bel’ula</i> ‘blouse’ (Sofia, 2;05)	<i>gla:s</i> → <i>gelase</i> ‘glass’
Greek (Kappa 2002)	Setswana (Batibo 1995)
b. Deletion	
<i>yr’afo</i> → <i>y’afo</i> ‘(I) write’ (Dionisis, 2;01)	<i>navra(tilova)</i> → <i>nala(t<sup>h</sup>inwowa)</i>
Greek (Tzakosta 2001)	Taiwanese Mandarin (Lin 1998)

But the similarities between child language and loanword adaptation do not involve data only.

There is a large body of research supporting the view that loanwords are adapted according to the rules or constraints of the borrowing language targeting aspects of phonological representation (Hyman 1970; Kaye & Nykiel 1979; Paradis & LaCharité 1997, 2001; Singh 1987; Uffmann 2004, 2001; Ulrich 1997). Under this view, the surface form of the source language constitutes the input to loanword adaptations and the adaptations are computed by the phonological grammar of the borrowing language. The same type of mechanism has been proposed as underlying children’s production (see section 8).

Moreover, there is an ongoing debate regarding the role of perception in loanword phonology, just like there is in child language (taking the form of the notorious ‘perception-production problem’ in the case of child language, see section 8). Several scholars propose that loanword adaptation is driven mainly by perceptual factors, which either act as triggers for the phonological processing of the word (Kenstowicz 2003; Steriade 2001) or function wholly outside the phonological component of the grammar (Peperkamp 2007; Peperkamp & Dupoux 2003). The latter approach finds support in experimental studies (Dehaene-Lambertz, Dupoux, & Gout 2000; Dupoux et al. 1999) showing that Japanese speakers have difficulties discriminating *ebzo* – a (cluster) sequence their language does not permit – and *ebɹzo*. Thus Peperkamp (2007), for example, proposes that, during perception, epenthesis in illegal sequences takes place. However, as Yip (2002) points out, such an approach cannot always be sustained: in Cantonese, which lacks TR clusters) some TR clusters undergo epenthesis (e.g. *plam* → *powlɐm* ‘plum’), while others undergo reduction (e.g. *fri:zə* → *fi:sa:* ‘freezer’). As a consequence, proposals that combine perceptual and phonological factors seem more appealing (Rose 1999a, 1999b; Yip 2002). It is interesting that such combined (perceptual and phonological) proposals have been developed at the same time that acquisitionists are independently exploring the role of perception (in addition to the broadly accepted role of the phonological component) in children’s mispronunciation of consonant clusters (see section 8).

With regard to the phonological mechanisms of the adaptation, it is often suggested that constraint-based models would provide the most suitable mechanism for the adaptation; in rule-based phonology, given that foreign words often contain illegal structures that are absent from underlying forms in native phonology, novel rules should be added to the grammar to deal with their adaptations (Peperkamp 2007)<sup>18</sup>. Within the principles and parameters model followed here, application of the existing principles and parameters of native phonology to the underlying form is sufficient to deal with the adaptations in a manner similar to child phonology. Let us consider the adaptation of the word *navratilova* in Taiwanese Mandarin that was given in 55, and in particular the first two syllables *navra* into *nala* (concentrating on

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<sup>18</sup> However, within constraint-based models, as well, it has been suggested that it is necessary to resort to constraints that are specific to loanword phonology (see Yip (2002)).



the prosodic change and ignoring the segmental change of the liquid). The original sequence, in a CVCV pattern, contains an empty nucleus.

57. *navra*

O	N	O	N	O	N
n	a	v	∅	r	a

Taiwanese Mandarin has a minus setting for the Nuclei+/-license parameter (no TR clusters in its native vocabulary). As a result, the grammar cannot establish a domain of infrasegmental government between the *v* and the *r*, which would satisfy the ECP and allow the output *navra*. The ECP thus demands that something be done about the empty nucleus. Taiwanese Mandarin chooses to delete the empty nucleus and the adjacent onset (containing the fricative) in order to rescue the structure.

58. Deletion: output *nara*

O	N	O	N	O	N
n	a	v	∅	r	a

As with child language, another possible strategy would be epenthesis of some melodic material to convert the empty nucleus into a full one. Interestingly, this option is taken by Chinese Mandarin, which adapts the word as *nafulatinwowa* (Lin (1998), cited in Yip (2002)). The relevant process is given in 59 below.

59. Epenthesis: output *navVra*

O	N	O	N	O	N
n	a	v	V	r	a

As far as the choice between epenthesis and deletion is concerned, it has been suggested that the choice is determined by phonological factors such as minimal word size (Yip 2002). For example the bisyllabic minimal word size in Cantonese determines that the monosyllabic *plam* becomes *powlɛm*, as opposed to the bisyllabic *fri:zə*, which becomes *fɿ:sa:*. Yip ((2002), after Steriade (2001)) also

argues that perceptual factors ('salience' of a segment) play a role in the choice; more salient segments tend to be preserved and epenthesis is instead used to break up the clusters. These factors have also been argued to play a role in child language (for word minimality see Kappa (2002), Fikkert (1994), for perceptibility Vanderweide (2005a, 2005b), more about perceptibility in chapter 3). Since either strategy would be equally appropriate to its use (in CVCV terms, satisfaction of ECP requirements), the choice depends on such grammatical as well as extragrammatical factors. An investigation of these factors in both adult and child language is essential in order to achieve a deeper understanding of the deletion and epenthesis processes. An investigation of these factors is also required for any potential explanation of children's preference of deletion, as opposed to the absence of such preference in loanword adaptation.

Finally, there are cases where the choice of deletion or epenthesis appears to be random. Such is the case of Taiwanese Mandarin and Chinese Mandarin, which are two varieties of the same language that show a clear tendency to follow different strategies without any apparent reason. Chinese Mandarin prefers epenthesis, while Taiwanese Mandarin favours deletion, even though the two varieties do not seem to have any relevant phonological difference that would justify this difference in choice (Yip 2002). The data in 60 (relevant consonants in bold) illustrate the different preferences (Lin (1998), cited in Yip (2002)).

#### 60. Epenthesis and deletion in varieties of Mandarin

Chinese: epenthesis	Taiwanese: deletion	English
<i>t<sup>h</sup>aj<sup>h</sup>tannik<sup>h</sup>ə</i>	<i>t<sup>h</sup>jetani</i>	Titanic
<i>pwot<sup>h</sup>ə</i>	<i>pi</i>	Burt (Reynolds)
<i>nafulatinwowa</i>	<i>nalat<sup>h</sup>inwowa</i>	Navratilova
<i>fulitəman</i>	<i>fuliman</i>	Friedman

It looks as if there is an amount of 'free choice' as to which strategy is chosen, which indicates that the nature of the process exceeds our current understanding.

In this section I argued that epenthesis and deletion in child language find a striking parallel in loanword adaptation, which can be analysed with the aid of the same phonological mechanism, with reference to language parameters and

principles, and in particular the Empty Category Principle. In the following section I discuss another such case, this time from (adult) native phonology.

## 7.2 Native phonology

### 7.2.0

In this section I present a case of empty nucleus and onset deletion from the (adult) phonology of French. In order to make the presentation clear, it is essential to introduce first another type of nucleus assumed in CVCV theory.

#### 7.2.1 Alternating nuclei

An alternating nucleus in CVCV is a nucleus that is lexically specified for segmental content but lacks an association line underlyingly (Scheer 2004), as seen in 61 below.

##### 61. Alternating nucleus

N

ə

For the surface manifestation of an alternating nucleus, there are two possibilities. When there is no association line, the vowel is not realised phonetically, as in 62a. It is only realised when linking of the melody occurs, as in 62b. This type of nucleus is called alternating because a vowel is realised in some forms of the word containing it, while it fails to surface in other forms of the word, so there is a vowel-zero alternation.

##### 62. Alternating nucleus: surface manifestation

###### a. unassociated: zero

N

ə

###### b. associated: vowel

N

|

ə

Evidence for alternating nuclei can be found in several languages, for example German, Polish, Czech, Moroccan Arabic, Turkish, Tangale, Hindi, etc.

Interestingly, different phonological traditions came independently to analyses requiring such underlying vowels. The issue of vowel zero alternations has sometimes been analysed as vowel insertion (Laskowski (1975) cited in Scheer (2004)), but there is also a wide literature on Slavic, which assumes a special type of vowels, called yers<sup>19</sup>, which appear in certain contexts only (Gussmann 1980; Kenstowicz & Rubach 1987; Rubach 1984; Spencer 1986b). At the same time, Government Phonology, was led to postulate such abstract vowels because of theory requirements such as structure preservation, and based on phenomena from a completely different set of languages, for example Moroccan Arabic (Kaye 1990, Kaye et al. 1990). The examples in 63 show words that in some forms contain a vowel and in others not (after Scheer (2004)). The vowel that alternates with zero is marked in bold.

### 63. Some vowel- zero alternations

	zero	vowel	vowel
a) Czech	<i>lokte</i>	<i>loket</i>	<i>loketni</i>
‘elbow’	GEN	NOM	ADJ
b) Moroccan Arabic	<i>k#bu</i>	<i>kt#b</i>	<i>k#t#b</i>
‘write’ PERF.ACT 3PL	3PL	3SG	3SG CAUS
c) Tangale	<i>dobgo</i>	<i>dobe</i>	<i>dobungo</i>
‘called’	‘called’	‘call’	‘called me’
d) Turkish	<i>devri</i>	<i>devir</i>	<i>devirden</i>
‘transfer’	ACC	NOM	ABL

In all these unrelated languages, however, the conditions for the appearance or not of a vowel are the same, and they are related to the following nucleus. The determining factor is government (proper government in Government Phonology

<sup>19</sup> For discussion of the facts in different Slavic languages, see Rowicka (1999) for Polish, Rubach (1993) for Russian, Scheer (1999) for Czech.

terminology see Kaye et al (1990)). Government originates from a following nucleus and can satisfy the ECP, repeated in 64.

#### 64. Empty Category Principle

A nucleus may remain unexpressed iff

- a) it is governed, or
- b) it is enclosed within a domain of infrasegmental government

Following the ECP, an alternating nucleus may remain phonetically unexpressed when it is governed, while it cannot if it is not governed. In the latter case, an association line is inserted and the vowel is pronounced. This is given schematically in 65.

#### 65. Alternating nucleus: surface manifestation

##### a) governed: zero



##### b) ungoverned: vowel



The preceding example shows a language with the parameter settings Nuclei +govern, Final empty nuclei-govern. In 65a the full nucleus governs the alternating nucleus, which remains silent, while in 65b the final empty nucleus is unable to govern the alternating vowel, which is thus forced to receive phonetic interpretation. Different combinations of parameter settings can produce different alternation patterns. Notice that the determining factor for the alternation is the nucleus that follows, since that is the source of the governing relation. According to Scheer (2004) governed alternating nuclei have no syntagmatic powers<sup>20</sup>: when such a nucleus is followed by an alternating nucleus in its (governed) silent version, it surfaces as a vowel: the following nucleus cannot govern it. As for ungoverned alternating nuclei, their power is parameterised: the setting of the parameter in the

<sup>20</sup> More precisely, governed nuclei of any type have no syntagmatic powers, the only exception to this generalisation being word final empty nuclei (see section 5.2).

language determines whether they have any power or not. What corresponds to a negative setting for government from alternating nuclei has been independently observed in the (Modern) Slavic literature (see footnote 21), where analyses suggest that the alternation depends on the identity of the following nucleus, that is whether it is a yer or not (Gussmann (1980), Kenstowicz (1987), Rubach (1984)).

To sum up, a) alternating nuclei remain silent if they are governed, while they surface if they are not and b) governed alternating nuclei have no syntagmatic powers (Scheer 2004). These two points will help us follow the presentation of an example of a deletion strategy in adult language.

### 7.3 ECP and cluster reduction in adult language

French is one of the languages that exhibit vowel-zero alternations. The French schwa is optionally omitted in certain positions. (Note that it takes part in the phenomenon of closed syllable adjustment, which means that it appears as [ɛ] in closed syllables and in open syllables when the following vowel is schwa (Dell (1995), Schane (1968), Tranel (1987), Valdman (1972))).

#### 66. Schwa-ε alternation

<i>apəle</i>	‘to call’
<i>apɛl</i>	‘call’ (noun)
<i>apɛləra</i>	‘he will call’

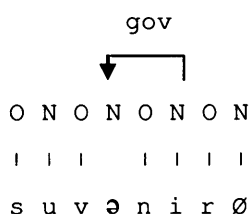
Anderson (1982) suggests that the French schwa is an empty nucleus, which can be optionally vocalised, and resorts to the mechanism of coda capture to account for the distribution. However, the phonological object of alternating nuclei we have introduced in the previous section, along with the parameterised syntagmatic relations are sufficient to capture the phenomenon (Scheer 2000b), without having to resort to coda capture, the validity of which is open to question (see Harris (1999)). French behaves like Slavic, and the alternating nucleus remains silent only if it is governed<sup>21</sup>. The following example shows how this happens.

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<sup>21</sup> To be more precise, in a series of schwas, any combination of them may remain silent, provided that two adjacent ones do not remain unexpressed. This has been known as ‘the law of three consonants’, (loi des trois consonnes), as that was formulated by Grammont (1914): ‘any schwa may

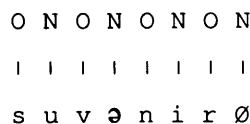
## 67. Optional government of schwa in French

### a. with government



*suvnir* 'to remember'

### b. without government



*suvənir* 'to remember'

In 67 the second nucleus is an alternating one. In 67b it is not governed and it gets linked and pronounced (output *suvənir*). In 67a the alternating nucleus is governed by the following full nucleus and can therefore remain silent. The ECP is satisfied, since the vowel that remains unexpressed is governed, and the output is *suvnir*.

Consequently, we would expect that, for a word like autrement *otrəmā* 'otherwise', the form *otrmā* would be possible, by government of the alternating nucleus (schwa). However, as pointed out by Charette (1990), who gives an analysis in standard Government Phonology, this form is not possible. The reason for this, in CVCV terminology, is that there is an empty nucleus in the TR cluster preceding the schwa. The representation, omitting any syntagmatic relations, would be as shown in 68.

### 68. 'autrement': partial representation

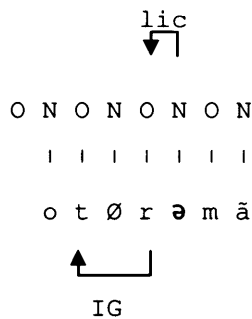



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be dropped provided that the result is not a sequence of three consonants'. This pattern is similar to that of Moroccan Arabic or Old Slavic, and it arises because in these languages alternating nuclei have the ability to govern. In Modern Slavic, on the other hand, alternating nuclei cannot govern, and therefore in a series of alternating vowels only the last one remains silent.

The ECP needs to be satisfied with respect to both the empty nucleus ( $\emptyset$ ) and the alternating one ( $\text{ə}$ ). If the alternating nucleus is not governed, the melodic material gets linked and the nucleus receives phonetic interpretation. It can then license the preceding sonorant to govern infrasegmentally the preceding obstruent (see section 4). This way, the ECP will be satisfied, since the empty nucleus will be in a domain of infrasegmental government, while the alternating one will be phonetically expressed. This corresponds to output *otrəmã* (69).

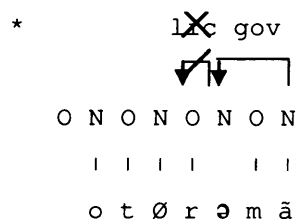
69. Without government: output *otrəmã*



*otrəmã* ‘otherwise’

On the other hand, output *otrmã* is ungrammatical because it would violate the ECP. The reason why the form *otrmã* is not possible is explained as follows. If the alternating nucleus received government and stayed unexpressed, it would not be able to license the preceding sonorant (remember that governed alternating nuclei have no syntagmatic powers) and the preceding empty nucleus would remain orphaned (neither governed, nor in a domain of infrasegmental government). The structure would involve an ECP violation and it would thus be ill-formed.

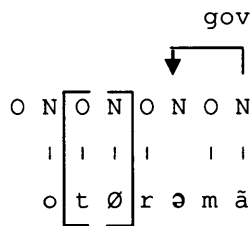
70. With government: ill-formed





However, the structure in 70 can be rescued by deletion of the empty nucleus (the ungoverned one inside the *tr* cluster) along with the following onset<sup>22</sup>, as shown in 71, resulting in output *otmã*<sup>23</sup>.

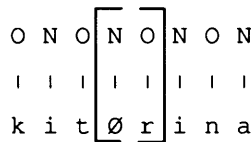
71. Rescuing strategy: output *otmã*



*otmã* 'otherwise'

The mechanism in action here is parallel to that applied to clusters of rising sonority in child language, as that is discussed in section 4. The example of the Greek word *k'itrina* 'yellow', pronounced by the child as *k'itina*, is repeated below, to facilitate comparison.

72. Rescuing strategy: output *k'itina*



In both cases, the ECP demands satisfaction, and the solution is deletion of the empty nucleus and of an adjacent onset. The same analysis can be applied to the

<sup>22</sup> Charette (1990, 1991) proposes that what happens is dissociation, not deletion. This is possible in Standard Government Phonology, but in CVCV this solution is not available. The reason is that in CVCV there is an empty nucleus after the onset (*t*), which cannot undergo dissociation (since it is empty) and thus needs to be deleted. Deletion of the nucleus without deletion of the adjacent onset (if we opted for dissociation of the consonant, as in Government Phonology) would create a CCV pattern, which is axiomatically impossible in CVCV theory.

<sup>23</sup> Note that output *otærmã* is not possible, because inside the domain of infrasegmental government (*tr*) there is an empty (not an alternating) nucleus.

Czech word *Kadlece* (genitive singular, family name), alternatively *Kadce* (Scheer 2004).

This example serves to show that potential ECP violations can result in cluster reduction in adult language, just as in child language.

## **8 The nature of child grammar**

### **8.1 Parameter setting**

So far, I have assumed, following Chomsky (1986) that parameters have a binary switch that can be either ON or OFF (plus or minus). Taken literally, this means that at certain points during the child's development there are sharp changes in the child's production. To take the example of the licensing parameter (Nuclei+/-license), we would expect that the child for some time produces no TR clusters all (parameter set to minus) and then suddenly starts producing all words with TR clusters correctly. However, this is not the case: child language is known to be inconsistent, and it always exhibits some amount of variation (see, e.g. Ingram (1986)). A child may produce a certain cluster correctly in one instance and incorrectly in another. Such variation in language acquisition is incompatible with the idea of categorical ON/OFF parameter switches.

Variation in child – as well as in adult – language has been the focus of several studies in phonology and several theoretical models have been put forward to account for it (for an overview, see Pierrehumbert (2001)). In particular, versions of Optimality Theoretic (constraint-based) models that claim to tackle the issue include Boersma's (1998) and Boersma & Hayes's (2001) Stochastic Optimality Theory, whereby constraint ranking is gradient and probabilistic (each constraint is linked to a probability distribution on a ranked scale), as well as Anttila's (1997) proposal of partially unranked constraints, and Anttila & Cho's (1998) model of multiple parallel grammars, where constraints may be unranked. In acquisition, Anttila's (1997) model is adopted by Velleman & Vihman (2002), while Tzakosta (2004), following Anttila & Cho (1998), develops a model of multiple parallel grammars of the acquisition of stress in Greek. The sheer number of studies dealing with variation within the Optimality Theory framework has led some researchers to conclude that Optimality Theory (as opposed to other frameworks) has the potential for explaining variation (Pierrehumbert 2001).

However, variable acquisition data can also be explained in a Principles-and-Parameters model, such as the one adopted here. Variable child data of the type described above can be interpreted as fluctuating of the learner between two settings of the parameter. This idea has been discussed in detail by Yang (2002), who proposes a Variational Learning model. Yang (2002) suggests that the learner can have both parameter values simultaneously; the input over time drives up the weight of the correct parameter value and drives down the weight of the incorrect value<sup>24</sup>. Yang illustrates how this proposal can explain empirical developmental data with a detailed analysis of Null Subjects in English children.

In this thesis I assume Yang's (2002) gradual setting of parameters, combined with Dresher and Kaye's (1990) cue-based learning. In Dresher & Kaye (1990) all parameters start with an unmarked setting and every parameter is associated with a cue that can trigger a change from the unmarked to the marked setting. Combining this with Yang's variational learning means that the learner starts with the unmarked setting for a given parameter and (if the appropriate cue-containing data are encountered) the marked value is gradually activated. Thus variable child data is due to incomplete activation of the marked value of the parameter, a state that occasionally allows the unmarked setting to determine the child's production. For the rest of this thesis, whenever I mention switching of a parameter to its marked value, I refer to it as an idealization of this gradual process of parameter setting.

## 8.2 The perception versus production problem

An idea that has been prominent in language acquisition research is that of continuity (Pinker 1984). According to the continuity assumption the child's cognitive and grammatical mechanisms are identical to those of an adult<sup>25</sup>. Continuity is more

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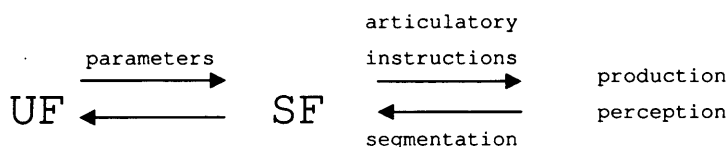
<sup>24</sup> Although Yang is credited with implementing this idea in language acquisition, variational learning models have been widely discussed within the computational as well as the connectionist literature (see for example, Attias (2001) and Frey & Hinton (1999)).

<sup>25</sup> In phonology this has been known as the strong identity hypothesis, which 'holds that child phonology is governed by the same rules as adult phonology' (Hale & Reiss 1998).

constrained than an alternative hypothesis that allows different structures or mechanisms for the two stages (child and adult) and it is thus preferable<sup>26</sup>.

Continuity would demand, among other things, that the architecture of the child's phonological grammar be the same as that of the adult. In rule-based or parametric systems an (adult) phonological grammar would have to include the following components in some form: a set of underlying forms (UF) and a set of rules or parameters that apply to the UF to produce the surface form (SF)<sup>27</sup> (Chomsky & Halle 1968). The SFs are then fed to the articulatory system for production. Inversely, for perception, the perceived forms serve as SFs, which are checked against the rules or parameters of the grammar so that the UFs can be reconstructed for word identification. The above simple model is given schematically below.

### 73. A model of adult perception-production



Continuity would dictate that the child's grammar has the same structure as the one in 73. However, it seems that such an analysis cannot be sustained. The main reason for this is that in the adult model the grammar can produce any of the forms (SF) that can be perceived (the same set of rules or parameters is used for both perception and production). Children, in contrast, seem to be able to perceive forms

<sup>26</sup> A hypothesis, often discussed as an alternative to continuity is maturation (Borer & Wexler (1987), Radford (1990) among many others), according to which certain parts (categories or principles) of the grammar are not present at the initial stage; rather, they develop gradually. However, both continuity and most versions of maturation agree that there are no principles that are child-specific (see, for example the maturational view proposed by Radford (1990)) and this is the point of interest here.

<sup>27</sup> In constraint-based systems, such as Optimality Theory, the same type of components is required: underlying form (input), constraints and surface form (output). The constraints do not apply to the underlying form, instead they are constraints on the surface form, but the function they serve is the same as in rule systems, namely to determine the surface forms based on the underlying form.

that they cannot produce, making the above model inappropriate. There is a notorious discrepancy between perception and production in child language. Children are able to understand adult forms that they are unable to produce. Comparative studies of cluster perception and production (Eilers & Oller 1976; Jongstra 2003) have shown that, although a production mistake sometimes reflects a perceptual mistake, very often perception is accurate while production is incorrect. Jongstra (2003), in his study of Dutch children's perception and production of consonant clusters found that most of the time perception is correct while production is incorrect. Children that could only produce singletons instead of clusters had no problems discriminating singletons from clusters.

The fact that children can parse forms that they cannot produce constitutes a problem for every acquisitionist and several ideas have been suggested towards its solution. One of these ideas is that the child's production does not reflect his/her competence, his/her grammar (Hale & Reiss 1998; Smith 2003). Hale & Reiss (1998) claim that it consists of systematic misarticulations, due to grammar external, performance factors. Smith (2003) suggests that the 'realisation rules' (that take the adult form as input and give the child's pronunciation as output) 'must be in some sense independent of competence.'

The view of production in child language as grammar external is rather appealing, since it eliminates the logical problem of having to postulate a grammar that can parse forms it cannot generate. However, there are reasons why such a solution is undesirable as compared to a grammar internal view of production. Firstly, several researchers (Levelt & van de Vijver 2004; Levelt, Schiller, & Levelt 2000; Pan 2005; Rose 2000) have argued that each stage of child language corresponds to an adult language. With regard to syllable structure, specifically, in any stage of language development, the syllable inventory (in the traditional definition of the syllable, e.g. CV, CVC, CCV etc) is attested in at least one adult language. Moreover, a number of studies analyse child language using parameters that are used in analyses of adult languages (e.g. Pan (2005), Pan & Snyder (2003))<sup>28</sup>. The present study is a contribution to this area of research, using only principles and parameters that are motivated from research in adult language in order

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<sup>28</sup> See also Stampe's (1969) proposal that there is a universal set of constraints, some of which have to be unlearned by the child during the acquisition process.

to analyse child language. There is also a great number of studies within the Optimality Theory framework that analyse child phonology using the same set of violable constraints as adult phonology (for example, Barlow (1997), Gnanadesikan (2004), Pater & Barlow (2003), Rose (2000, 2001), Tzakosta (2004)). Even phenomena that seem to appear exclusively in child language, such as consonant harmony, have been analysed without the aid of any child specific constraints (Rose 2000).

The implication of such a body of research is that a grammar external view of production in child language becomes redundant. The research mentioned above claims that production in child language exhibits the characteristics of adult languages, and it can be analysed with the aid of the same grammatical-phonological tools (principles and parameters, or constraints) as adult phonology. In comparison, models that employ different mechanisms for the analysis of adult and child language (principles and parameters or constraints for adult language, performance factors for child language) such as those suggested by Hale & Reiss (1998) and Smith (2003) are less parsimonious. Similarly, Smith's (1973) proposal of child-specific 'realisation' rules is equally undesirable since it involves a child-specific mechanism, even though, unlike performance proposals, this may be grammar internal.

However, even if we concede that production in child language can be analysed with the same principles and parameters as those active in adult production, we still have to acknowledge that the structure of children's language faculty is different, in some way, from that of the adult, in order to account for the perception-production discrepancy.

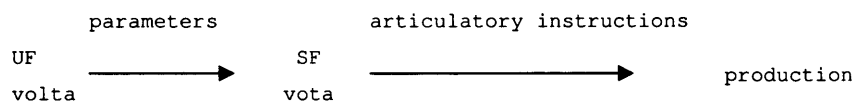
Let us go back to our schema in 73 of adult perception and production and try to apply it to child language. We could keep the production part unaltered (having, of course, the continuously changing parameter settings of the developing grammar mediating between UF and SF). In a word like *v<sup>l</sup>olta* ('walk' in Greek) the SF (the production form) of a child that produces no consonant clusters is *v<sup>l</sup>ota*. As for the child's UF, it is generally assumed that it is akin to the adult production form<sup>29</sup> (see e.g. Fikkert (1994), Gnanadesikan (1995), Goad & Rose (2003), Smith (1973)). Jongstra (2003) argues that this is not always the case: incorrect parsing can lead to

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<sup>29</sup> Note that UFs are gradually refined or altered, especially in the case of alternations.

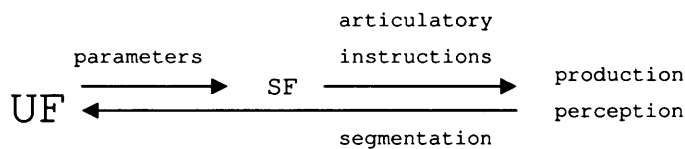
incorrect UFs. However, if the child can perceive the cluster correctly, this can be taken as an indication that s/he has the correct underlying form, including the cluster, in this case *v'olta*. The production process is the same as in the adult model described above.

#### 74. Production



In the case of perception, the situation is different. The child's surface (production) form, and the grammar (parameters, rules) that have produced it become irrelevant. The child's word identification is thus linked directly to the UF<sup>30</sup> (Macken 1980).

#### 75. A model of child perception-production



<sup>30</sup> An issue on which linguists seem unable to reach any consensus is whether the child's surface forms are stored in some kind of 'output lexicon' or not. 'Two lexicon' models (Menn 1978; Spencer 1986a) assume that the child has two different lexicons, one linked to perception and one to production, while 'one lexicon' models (Macken 1980) claim that there is only a single lexicon, linked to the child's perception.

The argument lies in whether children can manipulate their surface forms, which is taken as evidence that these forms are somehow stored (but see Smith (2003)). The type of evidence that is used to argue in favour of a two-lexicon account is, for instance, the case of Daniel (Menn (1971) cited in Menn & Matthei (1992)), an English-speaking child who had a nasal assimilation rule which turned 'beans' to *minz* and 'dance' to *næns*. The rule applied to all nasal-final words, but it did not, for some period of time, affect 'down' and 'stone', which had been – and continued to be – produced as *dæwn* and *don* respectively. The argument, according to Menn & Matthei (1992), is that in a one-lexicon approach, down and stone would have to be marked as exceptions to the assimilation rule, while in a two-lexicon model, this pattern can be attributed to the assumption that the forms *dæwn* and *don* were stored in the child's output lexicon and therefore resisted the rule.

The schema in 75 (child perception-production) is different from the one in 73 (adult perception-production). The major difference lies in the domain of application of parameters. In adult language, these determine both perception and production by linking UFs and SFs. In child language, parameters function in the same way for production (linking UFs to SFs), while they by-pass SFs in perception. Since this thesis is mainly concerned with cluster production, I do not discuss the mechanism of the perception process any further, leaving the issue for future research.

We have been forced to assume some difference between adult and child language, despite our expressed wish to abide by the continuity assumption. Indeed, a theory that assumes that child and adult language are *exactly* the same might be more parsimonious, but it would fail to account for the fact that the perception-production discrepancy exists in child language only. Any theory would therefore have to acknowledge some kind of difference between children and adults. The proposed model posits a structural difference as the cause of the observed difference between perception and production.

Moreover, there is a further important reason for ascribing a difference to children's language faculty: the existence of a so-called 'critical period' during which humans can acquire a first language successfully (Chomsky 1986). This covers the first few years of a human's life and constitutes a definite distinction between children and adults. Although our current understanding of this issue is limited, any theory of language (and language acquisition) will have to account for the fact that children have a mechanism that allows them to acquire a first language successfully, while adults do not. In the view put forward here, the difference consists in the relationship between perception and production (as well as in the child's ability to set parameters). The grammar itself abides by continuity: the same principles and parameters are active in both child and adult grammar, and every instance of child grammar is a possible adult grammar.

### **8.3 Cluster production**

Following the above reasoning and the discussion in the previous sections of this chapter, I now give a short example of the child's production of consonant



clusters (of the Greek word *v'olta* 'walk') in a CVCV parametric theory. The child's UF contains the same segments as the adult output, namely *v'olta*. According to a central axiom of CVCV, the representation contains a sequence of CV pairs with empty nuclei between any consecutive consonants. In the example in 76 there is an empty nucleus between the *l* and the *t*.

#### 76. *v'olta*: UF

O	N	O	N	O	N
v	o	l	∅	t	a

A short note on how such representations are constructed follows. The relevant algorithm will have to be able to distinguish potential consonant-like sounds from vowel-like sounds, and demand the insertion of an empty nucleus whenever it identifies two consecutive consonants. Naturally, initial representations will not be entirely accurate, since there are sounds that can be either under C or under V, depending on the grammar of the language, full knowledge of which the child does not have yet. Glides and syllabic consonants are typical such examples. Moreover, as the child initially has little knowledge of morphology, the gradual discovery of alternations will also change that UF.

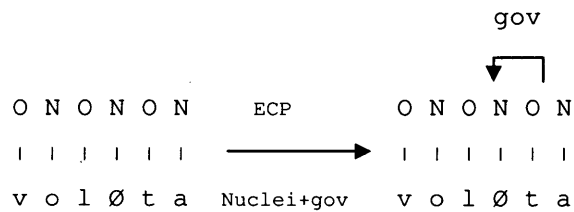
The SF is the result of the application of the child's grammar, with its principles and parameters. Let us consider the case of a section of a grammar that contains the ECP and the Nuclei +/-govern parameter at the plus setting.

#### 77. Mini Grammar 1

ECP: empty nuclei must be governed
Nuclei+govern

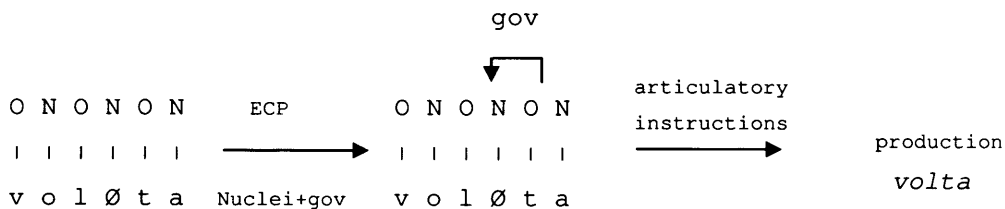
The application of this grammar to the UF in 76 would be as follows:

### 78. Production: mini grammar 1



The resulting representation is a well-formed one, and is fully pronounceable as *v'olta*. This is the point where competence ends, and performance begins: the form is subsequently fed to the articulators for production.

### 79. Production: mini grammar 1



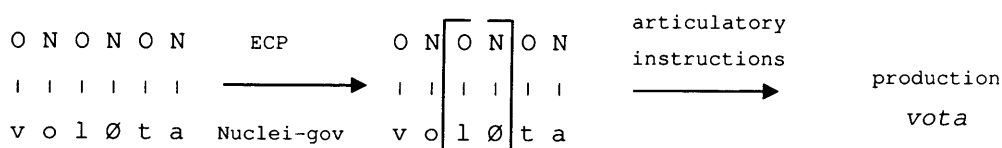
The case of a different grammar section, which contains the ECP but with the Nuclei +/-govern parameter still at its initial minus setting, is different.

### 80. Mini grammar 2

ECP: empty nuclei must be governed
Nuclei-govern

The application of this grammar to the UF in 76 would look as follows:

### 81. Production: mini grammar 2. I deletion

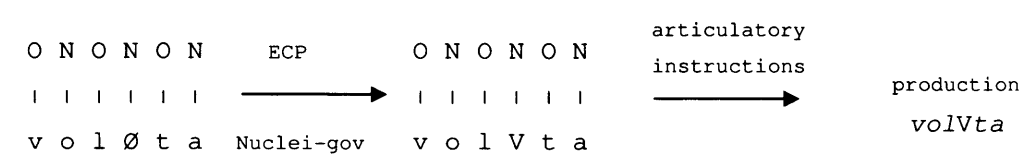


The Nuclei-govern setting means that the empty nucleus between the *l* and the *t* does not receive government. At the same time, the ECP demands that all empty nuclei

must be governed. As a result, a rescuing strategy will be put into action, in order for the ECP to be satisfied. The schema in 81 shows deletion of the empty nucleus along with the preceding onset. The outcome is the production form *vota*, as produced by the Greek child in example 1b, at the beginning of this chapter.

As discussed in previous sections, epenthesis is another possible strategy (82). Insertion of melodic material in the empty nucleus slot is also able to satisfy the ECP.

### 82. Production: mini grammar 2. II insertion



In this section, I discussed some problems that language acquisition research faces. Specifically, I presented my views on parameter setting and addressed the perception-production discrepancy in child language. Although I do not intend to settle the debate on these issues here, some basic assumptions on these issues were presented in order to help position the model of cluster acquisition proposed here in the wider frame of phonological acquisition and linguistic theory.

## 9 Conclusion

In this chapter I presented some of the mechanisms of CVCV theory and introduced a model of consonant cluster acquisition based on these mechanisms. A core assumption of the model is that cluster acquisition is determined by the gradual setting of a number of binary parameters to the correct value. In total, six parameters were discussed (83), plus one universal principle (84).

83. Parameter	Section
a. Nuclei+/- govern	2
b. Nuclei+/-license	4
c. Final empty nuclei+/-governed	3
d. Final empty nuclei+/-govern	5
e. Final empty nuclei+/-license	5
f. Initial ON Yes/No	6

#### 84. Empty Category Principle

A nucleus may remain unexpressed iff

- a) it is governed, or
- b) it is enclosed within a domain of infrasegmental government

I showed how a model using these parameters and principle can account for familiar data from acquisition of consonant clusters.

## CHAPTER 3. TT CLUSTERS

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### 1 Introduction

In this chapter I test some predictions made by the CVCV acquisition model outlined in chapter 2. Specifically, I examine the prediction that word medial clusters of non-rising sonority (TT) are acquired before the corresponding word initial ones. This is done with an experiment testing Greek children's production of these clusters. The experimental results are consistent with the prediction. They also open a number of other questions. In particular, the data are also compatible with the Licensing-by-cue acquisition model. It is therefore essential to test an area where the two theories (CVCV and Licensing-by-cue) make different predictions. I thus proceed to a second experiment, testing children's production of word initial versus word medial TR clusters. The Licensing-by-cue model would predict a difference in their acquisition while, according to the CVCV model, there should be no difference between the two positions. The results are consistent with the CVCV model.

### 2 The TT experiment

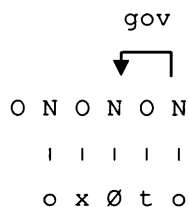
#### 2.1 The prediction

A prediction made by the system that I developed in chapter 2 concerns the order of appearance of TT clusters. The prediction is that the child will acquire word medial TT clusters before word initial ones.

Recall that the requirement for the existence of word medial TT clusters is that the parameter that regulates government originating from full nuclei must be

plus (Nuclei+govern, see discussion chapter 2, section 2). The example that follows shows the representation of the Greek word *oxt'o*.

### 1. Word medial TT clusters: government



*oxt'o* 'eight'

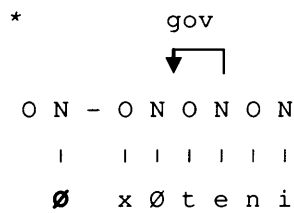
In 1, the empty nucleus is governed by the following (full) nucleus, and the ECP is thus satisfied. A positive setting for the government parameter is necessary for the existence of word medial clusters of non-rising sonority. In the case of a grammar with a negative setting for the parameter (Nuclei-govern), such clusters could not exist, because failure to govern the empty nucleus would constitute a violation of the ECP.

### 2. *oxt'o* in a grammar with Nuclei-govern: ill formed



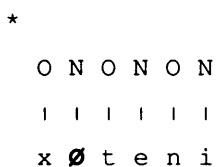
On the other hand, in order for initial TT clusters to exist, two marked parameter settings are required: full nuclei must be able to govern (Nuclei+govern), and in addition the grammar must not have an initial ON pair (Initial ON No) (see chapter 2, section 6). Both these conditions are necessary for the existence of these clusters. In a grammar with Nuclei+govern but Initial ON Yes parameter settings, these clusters are disallowed; the relevant structure is ill-formed, because of failure to satisfy the ECP (the initial empty nucleus is not governed). I illustrate this with the representation of the Greek word *xt'eni* ('comb') in 3 below.

3. *xt'eni* in a grammar with Initial ON Yes and Nuclei+govern: ill formed



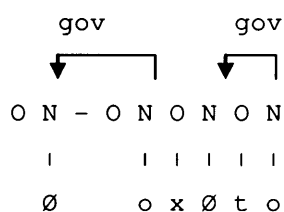
Similarly, in 4 I show the representation of the word *xt'eni* in a grammar without an Initial ON but with a Nuclei-govern setting. The structure is ill formed, because of failure to satisfy the ECP (the empty nucleus is ungoverned).

4. *xt'eni* in a grammar with Initial ON No and Nuclei-govern: ill formed



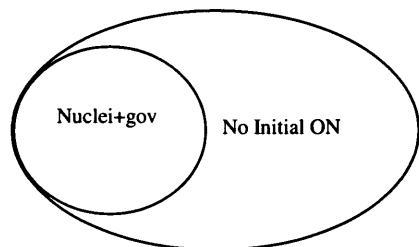
Recall that in the case of word medial clusters, the setting of the Initial ON parameter is irrelevant (see discussion in chapter 2, section 6.3). Word medial clusters are allowed in a grammar with Initial ON No setting, as shown in 1 above, but also in a grammar with Initial ON Yes setting, as shown in example 5 below.

5. *oxt'o* in a grammar with Initial ON Yes: output *oxt'o*



The only requirement for the existence of word medial clusters of non-rising sonority is a marked setting of the Nuclei+/-govern parameter. Compare this with the requirements for such word initial clusters: Nuclei+/-govern, No initial ON. The conditions for the existence of word internal TT clusters constitute a proper subset of those for the existence of word initial TT clusters (6).

## 6. A subset relation



Small oval: conditions for word medial TT

Large oval: conditions for word initial TT

Thus, whenever a (child) grammar allows TT clusters word initially, we expect to find TT clusters word internally, too.

Although no developmental study has been done specifically for this, the available data do not seem to falsify this prediction. For example, Kappa (2002) analyses the phonological development of a child acquiring Greek and gives examples of cluster simplifications at different points in the child's development. The child continues to simplify initial TT clusters up to an age when internal TT cluster simplification appears to have stopped (*xtes* → *tes* 'yesterday' age 2;10,2), indicating that she has probably mastered the production of internal TT clusters before mastering the production of the initial ones. However, careful observation or experimentation is required in this area.

## 2.2 Goal of the experiment

The goal of this experiment is to test whether Greek children acquire word initial TT clusters after the corresponding word medial ones. In order to test this, I examined children's production of these clusters.

According to the experimental hypothesis ( $H_1$ ) we expect that children will perform better at word medial clusters than at word initial ones. The null hypothesis ( $H_0$ ) is that there will be no difference in performance.



7.  $H_1$  -TT > #TT > better performance  
 $H_0$  -TT = #TT = similar performance

## 2.3 Methods and materials

### 2.3.1 Subjects

Fifty-nine monolingual Greek children were tested (21 boys and 38 girls). Nine more children were excluded from the study, since they refused to cooperate or did not manage to complete the task. The age range was from 2;03 to 5;00, mean age 3;08. (see appendix for information on subjects). The experiments took place in four different nurseries in Crete (three in Rethymno and one in Iraklio) and, in the case of one child only, in a relative's house.

The children were selected according to linguistic and general developmental criteria. The developmental criteria required normal development, i.e. no background of cognitive, behavioural, hearing or physical impairment. I asked the nursery staff whether the child had any relevant problems. All fifty-nine children participating in this study were reported by staff as being healthy. The linguistic criteria required that i) the child's native language be Greek, ii) the child be raised in a monolingual environment iii) the child have a normal linguistic development iv) the child be able to produce at least some consonant clusters. Finally, the children had to be willing to participate in a non-word repetition task.

### 2.3.2 Methodology

A non word repetition task was used. Children were asked to repeat novel, made-up words that had the desired structures. The task was chosen for its effectiveness in producing a large amount of relevant data, compared to spontaneous production. Also, novel words allowed me to control for familiarity effects, which would be present in imitation tasks containing existing words. Furthermore, using nonsense words allowed me to control the phonological environment of the clusters across conditions.

Non-word repetition has been used mainly as a test of working memory (e.g. Gathercole (1995), Gathercole et al (1994), Laws (1998), cf. van der Lely & Howard (1993)) and has been proposed as a screening measure for language impairment (e.g. Dollaghan & Campbell (1998), Weismer et al (2000)), but it is also used in studies

examining young children's acquisition of phonology (e.g. Kirk & Demuth (2006), Zamuner & Gerken (1998), Zamuner et al (2004)). Kirk & Demuth (2006), for example, used a non-word repetition task in order to examine English children's production of coda consonants. Although it has been suggested that imitative speech may not tap into the child's phonological system in the same way as spontaneous speech, there are results showing that the patterns found in imitation tasks are similar to those found in spontaneous speech. For instance, a production study by Kehoe & Stoel-Gammon (2001) showed no difference in the accuracy of children's imitated and spontaneous productions.

Extra care was taken to ensure the naturalness of the task. Firstly, the words were paired with pictures of novel animals, so that the words would have a referent; I thus made sure that the task is a linguistic one (rather than a general non-linguistic sound-production task). Secondly, the children did not hear the stimuli from a recording, but from a person (the experimenter), something that is more likely to occur in everyday life. Later evaluation of the spoken stimuli words by the experimenter showed consistent use of appropriate stress and segmental content. Thirdly, the task was not presented to the children as a request to repeat words, but as a game in which they were taking active part. The game was designed in a way that reflected real life interactions (see procedure).

I have good reasons to believe that I have succeeded in making the task natural and linguistic. Apart from the reassuring fact that children were enjoying the 'game' and some were asking for more, they were making comments that indicated that they were in an everyday situation, one that could have taken place in their classroom, and not just in an artificial experimental environment; for example: 'Will my sister meet these animals, too?' (Argiro 4;01).

Moreover, some children formed diminutives out of some words, in the regular way for Greek nouns. In the case of neuter nouns this is done by adding *-aki* to the stem of the noun, after removing the inflectional ending. So, for example, an animal called *kixr<sup>1</sup>o<sup>1</sup>* became *to mikr<sup>1</sup>o kixr<sup>1</sup>aki*.

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<sup>1</sup> This word is not one of the forms discussed in this section. It was used in one of the series of tests that I conducted with these children (see section 3).

8. *to mikr'o kixr'aki*  
 the.N.SG little.N.SG kixro.N.SG.DIM  
 'the little kixro'

This involved recognising the word as a neuter singular noun by the ending *-o*, removing the ending and adding the diminutive suffix. This was a linguistic operation that could not be carried out unless the child was involved in a linguistic task.

### 2.3.3 Materials

There were two conditions in the experiment; the first condition involved words with clusters of non-rising sonority (obstruent-obstruent clusters) in initial position, and the second condition contained words with the same clusters in medial position. Specifically, the following clusters were tested:

9. *ft, xt, vð, γð, vy*

These clusters can be found in Greek words both in word initial and word medial position. Some (real) Greek words containing them are listed below.

#### 10. a. Word initial position

- ft'ino* 'spit' 1<sup>ST</sup> SG  
*xt'eni* 'comb'  
*vðom'aða* 'week'  
*γð'ino* 'undress' 1<sup>ST</sup> SG  
*vy'azo* 'take off' (remove) 1<sup>ST</sup> SG

#### b. Word medial position

- kaft'os* 'burning (hot)'  
*pixt'os* 'thick' (dense)  
*ravð'i* 'stick'  
*liγða* 'dirt'

*kavy<sup>1</sup>as* ‘fight’

The construction of the nonwords used in the experiment followed the phonotactics of Greek. The words were either feminine or neuter nouns, with inflectional endings *-a* (feminine), *-i* (feminine or neuter), or *-o* (neuter). No masculine endings were used, because they involve (in the nominative) a word final consonant (*-s*), and that would increase the structural complexity of these trials. All words were bisyllabic, with a voiceless stop (*p*, *t* or *k*) as an onset for the non target syllable. There were five stimuli in each condition. The stimuli of the first condition were the following:

11. *ft<sup>1</sup>ipo*, *xt<sup>1</sup>ika*, *vð<sup>1</sup>ito*, *γð<sup>1</sup>oki<sup>2</sup>*, *vγ<sup>1</sup>api*.

The stimuli of the second condition were formed by reversing the syllable order. The stimuli were the following:

12. *pof<sup>1</sup>i*, *kax<sup>1</sup>i*, *to<sup>1</sup>vð<sup>1</sup>i*, *ki<sup>1</sup>γð<sup>1</sup>o*, *piv<sup>1</sup>a*.

For uniformity, the target cluster always preceded the stressed vowel. This creates pairs such as *ft<sup>1</sup>ipo* – *pof<sup>1</sup>i*. Note that both members of these pairs are well-formed in Greek, which is characterised by a lexical accent system, restricted by the trisyllabic window (i.e. stress must fall in one of the last three syllables of the word). For analyses of the Greek stress system see Arvaniti (1991), Drachman & Malikouti-Drachman (1999), Malikouti-Drachman (1989), Philippaki-Warbuton (1976), Ralli (1988), Revithiadou (1999). For the acquisition of stress in Greek see Tzakosta (2003, 2004).

The child’s production of singletons was not systematically tested. The rationale for this is that words with singletons would be produced spontaneously

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<sup>2</sup> Notice that *k* in Greek (and all the other velar consonants) becomes palatal before a front vowel. For example, *γð<sup>1</sup>oki* would be pronounced [γð<sup>1</sup>oci]. In Cretan dialects, the velar might undergo even further fronting (Newton 1972). Indeed, all children exhibited some degree of fronting, the extent of which depended on the child’s background. However, that does not affect our experiment in any crucial way. The stimulus producer’s dialect has moderate fronting, typical of Cretan urban areas.

during the session (see procedure). Avoiding testing singletons leaves more room for testing as many cluster words as possible.

#### **2.3.4 Procedure**

I first spent some time with the children in the classroom, taking part in their activities, so that I would become familiar to the children. After selecting children according to the linguistic and general developmental criteria discussed above, I tested each of the selected children individually in a separate room. Each session lasted about half an hour.

This test was performed together with a series of other tests, some of which are described later in this thesis. As a result, the total number of test items was fifty-eight. The test items were arranged in three different pseudo-random<sup>3</sup> orders so as to avoid sequence effects, and each of these orders was followed for a third of the children tested. There were four warm-up items without any clusters. The answer sheets with the three stimulus orders are given in the appendix.

Pictures of novel animal were put inside a Russian doll representing a wizard. The child was told that the wizard had eaten some strange animals, and that he/she could free them by calling each animal with their name. The child was then invited to open the wizard, take out the animals one by one, and say their name. If after two attempts the child was not replying, we would move on to the next animal/ word, and the word would be added to the end of the list as the name of some other animal. The same (that is repetition of the word at the end) was done for words that were obscured by background noise. Designing the session in a way that involves an active task ensured that children's interest was kept throughout the experimental session.

Moreover, in order to vary the task, not all the pictures were inside the wizard-doll. Some were 'sleeping' inside a fairy's dress and the child was asked to wake them up, others were hiding inside a box with a small opening, through which only the child's hand could go, some others were absorbed in reading a book and got lost in its pages, some were in the belly of a smaller Russian doll representing a girl, where they went to keep warm, and, finally, some were hiding inside a pair of

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<sup>3</sup> Items were put in a random order, and then sequences consisting of three or more items belonging to the same category were broken up.

trousers, and the child was asked to find them so that I could put on my trousers. This way, the children's attention was constantly renewed and sessions were enjoyable for both the children and the experimenter.

During the session, there were spontaneous conversations between the child and the experimenter before, during and after the task with the intention of giving the child and the experimenter some rest and keeping the child's attention. From these conversations (all DAT-recorded) information on the child's production of singletons was extracted.

### 2.3.5 Transcription and coding

The responses were transcribed on-line by the experimenter. The transcription was done in a fairly broad way, using the International Phonetic Alphabet. The sessions were also DAT recorded. The original transcriptions were then checked and amended off-line by the experimenter, with the aid of spectrographic analysis when necessary. Spectrographic analysis was used when a response was not entirely clear, and there was doubt as to the identity of the relevant consonants. Responses that were inaudible or covered by background noise were excluded<sup>4</sup>.

An independent transcription was made by a second transcriber, who is a Greek native speaker and is well-trained in doing transcriptions. Ten percent of the data were cross-checked. In particular, one-tenth of the responses of each child were transcribed. The consistency rate between the two transcriptions, focusing on the cluster data, was 96 percent.

Moreover, notes were taken during the experiment and during the analysis of the recordings regarding any peculiarities of the child's speech. Specifically, care was taken to note any consistent substitutions that the child was making (in single consonant production). One such substitution was the substitution of *l* for *r* (13), and another common substitution was that of *θ* for *s* (14).

#### 13. *l* for *r* substitution (Emanouela 4;11,21)

##### a. Single consonant production

*or<sup>l</sup>ea* → *ol<sup>l</sup>ea* 'pretty' N.PL

*xor<sup>l</sup>ai* → *xol<sup>l</sup>ai* 'fit' 3<sup>RD</sup> SG

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<sup>4</sup> In all tests such cases were between 0 and 0.7 percent of total responses.

b. Cluster production

*kart'i* → *kalt'i*

*kixr'o* → *kixl'o*

14. *θ* for *s* substitution (Kali 3;00,03)

a. Single consonant production

*pol'es* → *pol'eθ* 'many' F.PL

b. Cluster production

*st'ipo* → *θt'ipo*

*sf'ito* → *θf'ito*

Responses that involved one of these two substitutions were coded as correct.

During the coding, only changes in the consonant cluster were considered. Changes of any other consonant, any vowel or stress were ignored. Vowels were seldom changed, and neither was the stress pattern. In the few monosyllabic responses the dropped vowel was the non-stressed one. Such responses were coded according to the consonant(s) that preceded the vowel. The codes used are given in the next section.

## 2.4 Results

### 2.4.1 General results

Table 1 shows the categories used for coding the responses, with some examples. A short explanation of the code names and more examples follow.

Table 1. Categories used in coding with examples of corresponding responses.

Code	Stimulus	Response
Correct	<i>ft'ipo</i>	<i>ft'ipo</i>
Drops 1 <sup>st</sup>	<i>xt'ika</i>	<i>t'ika</i>
Drops 2 <sup>nd</sup>	<i>γð'oki</i>	<i>γ'oki</i>
Other single	<i>xt'ika</i>	<i>p'ika</i>
Change one	<i>vð'ito</i>	<i>vl'ito</i>
Other	<i>vγ'api</i>	<i>γl'api</i>

‘Correct’ indicates a target cluster. For instance:

15. *vð'ito* → *vð'ito* (Emanouela 4;11,21)

*ft'ipo* → *ft'ipo* (Katerina 3;11,25)

*xt'ika* → *xt'ika* (Nikos 4;03,17)

‘Drops 1<sup>st</sup>’ indicates that the child drops the first of the two consonants. For example:

16. *γð'oki* → *ð'oki* (Mairi 4;04,01)

*ft'ipo* → *t'ipo* (Aglaia 3;03)

*xt'ika* → *t'ika* (Manolis 3;10,01)

*vγ'api* → *γ'api* (Andreas 4;03,16)

In ‘Drops 2<sup>nd</sup>’ the child drops the second consonant of the cluster.

17. *γð'oki* → *γ'oki* (Sofia 3;01)

*tovð'i* → *tov'i* (Nikolas 2;10,29)

*vγ'api* → *v'api* (Antonis 3;06,04)

I coded as ‘other single’ responses that consisted of a single consonant that was neither of the two consonants of the stimulus cluster.



18.  $\gamma\delta^l oki \rightarrow v^l oki$  (Marios 3;01)  
 $v\gamma^l api \rightarrow x^l api$  (Mario 3;03,01)  
 $x^l ika \rightarrow p^l ika$  (Manouela 2;11,19)

‘Change one’ were the responses in which the child had altered one of the two consonants in any way.

19.  $v\delta^l ito \rightarrow vl^l ito$  (Marilena 3;10,27)  
 $x^l ika \rightarrow ft^l ika$  (Mirto 3;00)  
 $ft^l ipo \rightarrow st^l ipo$  (Agelos 3;04,12)

Finally, ‘other’ indicates any response that does not fit into one of the above categories. This might involve a different cluster, epenthesis or metathesis of the cluster members.

20.  $\gamma\delta^l oki \rightarrow xr^l oki$  (Agelos 3;10,12)  
 $v\gamma^l api \rightarrow \gamma l^l api$  (Manos 3;04,04)  
 $\gamma\delta^l oki \rightarrow dr^l oki$  (Natalia 4;03,24)

Following the coding mentioned above, the results for word initial clusters are given in Table 2. The table shows the percentage of each response type, which was calculated on the basis of conflated raw figures. This method of calculation was possible because of the structure of our data: there was an equal amount of data for each child. The same method of calculation is followed throughout this thesis, unless otherwise stated.

	Number of responses	Response percentage
Correct	124	42
Drops 2 <sup>nd</sup> cons.	23	7.8
Drops 1 <sup>st</sup> cons.	56	19
Other single cons.	29	9.8
Consonant epenthesis	4	1.4
Other cluster	16	5.4
Changes one con.	43	14.6
Total	295	100

Table 2. Word initial TT clusters (n=295), raw figures and percentage of responses by category for all children combined

The percentages of the major response categories are also presented in a visually friendlier form in figure 1 below. From now on, only such percentage figures will be given in the main text, while the corresponding tables will be given in the appendix.

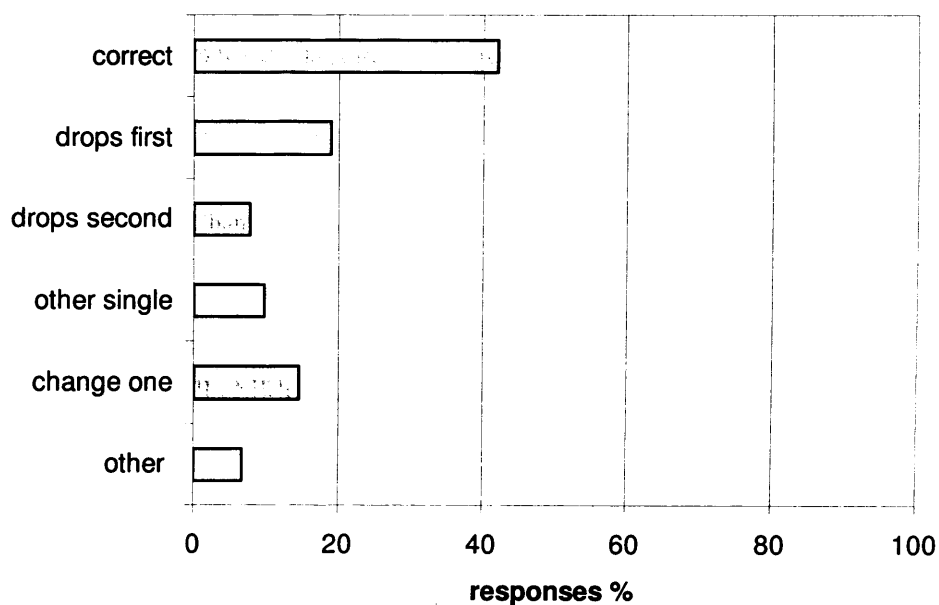


Fig. 1. Word initial TT clusters (n=295), percentage of responses by category for all children combined.

Children produced the target cluster 42 percent of the time. The most common mistake was dropping of the first consonant, while the second one was dropped far less often.

In 21-26 I give some examples of children's responses in the word medial condition.

21. Correct

*kaxt'i* → *kaxt'i* (Sofia 3;01)

*kiyð'o* → *kiyð'o* (Kostas 4;05)

*pivy'a* → *pivy'a* (Sotiria 5;00,16)

22. Drops 1<sup>st</sup>

*poft'i* → *por'i* (Vagelio 2;10,07)

*kaxt'i* → *kat'i* (Mariana 3;07,17)

*pivy'a* → *piy'a* (Kali 3;00,03)

*kiyð'o* → *kið'o* (Andreas 4;03,16)

23. Drops 2<sup>nd</sup>

*poft'i* → *poft'i* (Manolis 3;10,01)

*kiyð'o* → *kiy'o* (Pantelis 3;01,29)

*tovð'i* → *tov'i* (Nikolas 2;10,29)

24. Other single

*kiyð'o* → *kiv'o* (Vagelio 2;10,07)

*pivy'a* → *pik'a* (Maraki 3;05,03)

25. Change one

*tovð'i* → *tuvt'i* (Manouela 2;11,19)

*kaxt'i* → *kart'i* (Manolis 3;10,01)

26. Other

*tovð'i* → *toðv'i* (Kleri 4;03,06)

*kiyð'o* → *ixt'o* (Manolio 3;06,17)

*kiyð'o* → *kivl'o* (Nikolas 2;10,29)

Figure 2 contains the results in the word medial condition.

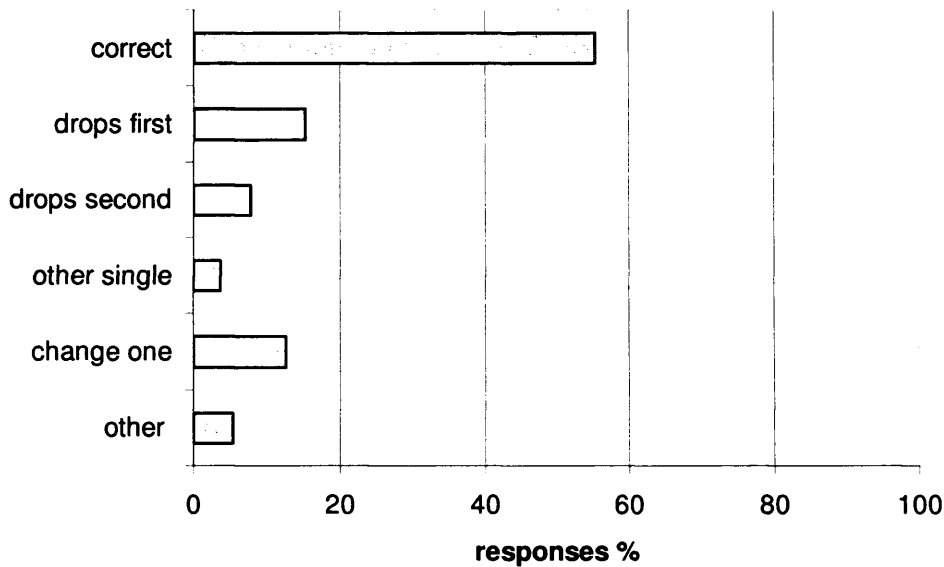


Fig. 2 Word medial TT clusters (n=295), percentage of responses by category for all children combined

In the word medial condition, target responses were given more than half of the time. The first most common mistake was dropping of the first consonant, while the second one was dropped about half as often.

#### 2.4.2 Directionality of cluster reduction

In this section, I present results regarding the question of which consonant is dropped in cluster reduction. The reason for making special reference to this issue, which is not related to our experimental question, is that the experiment provides new data, from a cluster type that has not been previously studied.

With regard to the word initial condition, a one variable chi-square test was performed to test whether the two consonants were dropped equally often. The  $\chi^2$  value of 13.785 DF=1 was found to have an associated probability value of 0.001. Based on this statistically significant result, we can conclude that the two consonants

were not dropped equally often. Figure 1 shows that dropping of the first consonant was the more popular strategy.

Similarly, in the word medial condition, a one variable chi-square test gave a  $\chi^2$  value of 7.118 DF=1 with an associated probability value of 0.008. We can conclude that the difference between dropping of the first consonant and dropping of the second consonant is statistically significant. Figure 2 shows that the first consonant was dropped more often than the second one.

In a further examination of cluster reduction, the clusters tested can be divided into two sub-categories, fricative-stop clusters (*ft, xt*) and fricative-fricative clusters (*vð, ʒð, vʒ*). Figure 3 shows the percentage of deletion of the first consonant for the two sub-categories in word initial position (for results table see appendix).

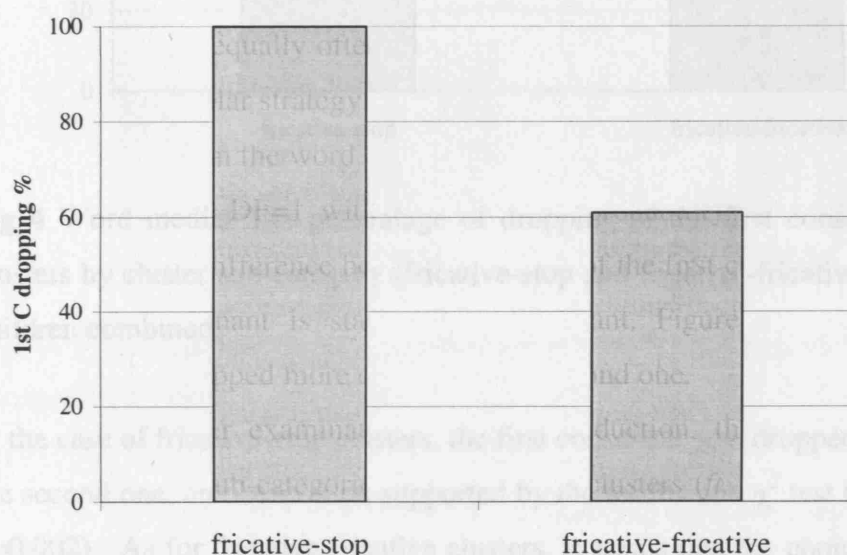


Fig 3 Word initial TT: percentage of dropping of the first consonant in reduced clusters by cluster sub-category (fricative-stop and fricative-fricative clusters) for all children combined

In the fricative-stop category, 100 percent of the consonant deletion involved the first consonant, in line with our previous discussion. In the case of fricative-fricative clusters the difference between dropping of the first and the second consonant looks rather small (around 60% and 40% respectively). A one variable chi-square test confirmed that the difference is not statistically significant ( $\chi^2=2.864$ , DF=1,

p=0.091). Finally, the difference between the two sub-categories was statistically significant ( $\chi^2=10.999$ , DF=1, p=0.001).

The results of the word medial context look very similar to the word initial results, with a difference between the two sub-categories. Figure 4 shows the percentage of dropping of the first consonant by sub-category (for results table see appendix).

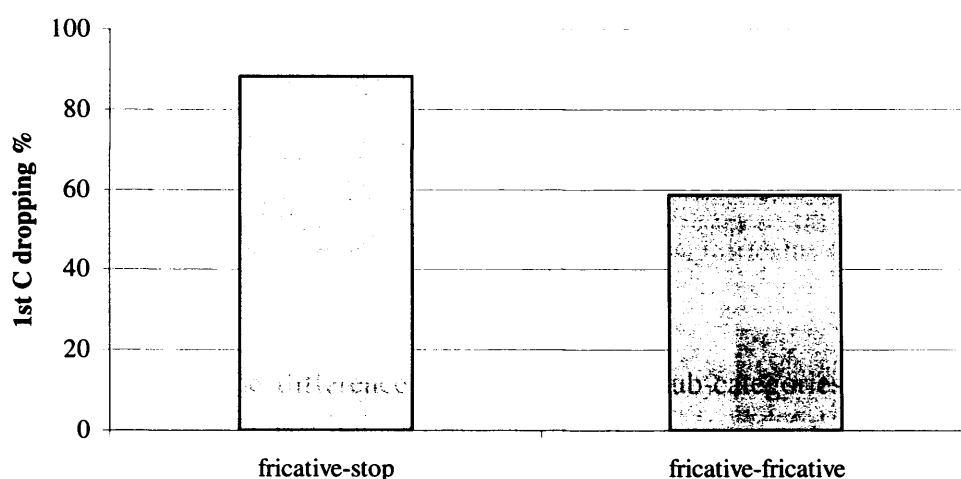


Fig 4 Word medial TT: percentage of dropping of the first consonant in reduced clusters by cluster sub-category (fricative-stop and fricative-fricative clusters) for all children combined

In the case of fricative-stop clusters, the first consonant was dropped more often than the second one, an observation supported by the results of a  $\chi^2$  test ( $\chi^2=9.941$ , DF=1, p=0.002). As for fricative-fricative clusters, it seems that the choice is chance. The chi-square test gave a  $\chi^2$  value of 1.588 DF=1 with an associated probability value of 0.208, showing no significant difference between dropping of the first and second consonant. Moreover, as in the word initial position, there was a statistically significant difference between sub-categories ( $\chi^2=3.979$ , DF=1, p=0.046).

Finally, position (word initial versus word medial) was not found to have an effect on the choice of consonant, either in the fricative-stop subcategory ( $\chi^2=2.487$ , DF=1, p=0.115) or in the fricative-fricative sub-category ( $\chi^2=0.036$ , DF=1, p=0.850).

Such results are consistent with the general tendency reported in language acquisition studies, of dropping the most sonorous consonant and retaining the less sonorous one (e.g. Gnanadesikan (2004), Ohala (1999), Pater & Barlow (2003), see

chapter 1, section 3.3). In fricative-stop clusters, the fricative was dropped more often, while in fricative-fricative clusters, either of the two fricatives was dropped.

### 2.4.3 #TT versus -TT

In a comparison of the performance in the two positions, a difference appears. Children gave correct responses 42 percent of the time in word initial position versus 55.3 percent in medial position (Figure 5).

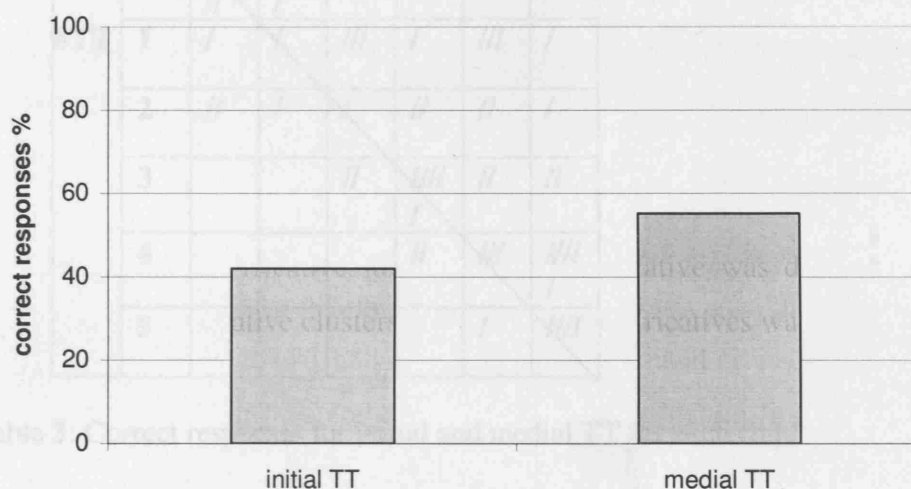


Fig. 5 Percentage of correct responses for word initial versus word medial TT clusters for all children combined

A chi-square test was carried out to discover whether there was a significant relationship between position and performance (number of correct responses). The  $\chi^2$  value of 10.319 had an associated probability value of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between position and performance. As seen in figure 5, children's performance was better in word medial position.

Furthermore, I present below a table containing the number of correct responses for each child in the word initial and word medial condition. The reason for such an arrangement of the data lies in the nature of the prediction. The model expects that each child will acquire initial TT no sooner than medial TT. The chi-square test mentioned above was performed on the summed responses of all

children, without looking into the results of each individual child. Consequently, even if the results were consistent with the model, the possibility of having unexpected results for some of the children remains open. This is the question that the organisation of data in table 3 tackles.

		-TT					
#TT		0	1	2	3	4	5
	0	//// //	//// /	//	/		
	1	/	/	///	/	///	/
	2	//	/	/	//	//	/
	3			//	/// /	//	//
	4				//	///	/// /
	5					/	///

Table 3: Correct responses for initial and medial TT for each child

The vertical dimension represents the number of correct responses in the word initial condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the word medial condition (again from zero to five). Each tally mark in the table cells represents a child (total 59 children). One can therefore read out of the table the number of correct responses each child gave in the two conditions. For example, fourteen children (in the first row) gave no correct responses in the initial condition. Of these children, six (in the first cell starting from the left hand side) gave no correct responses in the word medial position either, five (in the second cell) gave one correct response, two (third cell) two correct responses and so on. Children are divided into two groups, represented by the two sectors, divided by the diagonal: the top right sector contains children that performed better at medial TT, while the bottom left sector consists of children that performed better at initial TT. Children that fall on the diagonal performed the same in both conditions.



We expect that the top right sector will contain a greater number of children than the bottom left sector, an indication that most children perform better at medial TT than initial TT.

A visual examination of the table shows that most children performed better at medial TT than at initial TT. The top right sector is populated much more than the bottom left one. There is a large number of children that performed well at -TT and badly at #TT, while there were few children that performed better at #TT than at -TT<sup>5</sup>. Some examples of individual children's performance are given below. Kostantinos (27a) performed adult-like in the word medial condition, while his performance in the word initial condition was very poor. Manouela's performance (27c) was very poor in both conditions, while Mario (27b) gave target responses about half of the time in both conditions.

27. a. Kostantinos (2;11,17)

-TT: 5 out of 5 target	#TT: 1 out of 5 target
<i>pof't'i</i> → <i>pof't'i</i>	<i>ft'ipo</i> → <i>ft'ipo</i>
<i>kax't'i</i> → <i>kax't'i</i>	<i>xt'ika</i> → <i>t'ixa</i>
<i>tovð'i</i> → <i>tovð'i</i>	<i>vð'ito</i> → <i>v'ito</i>
<i>kiyð'o</i> → <i>kiyð'o</i>	<i>γð'oki</i> → <i>ð'oki</i>
<i>pivy'a</i> → <i>pivy'a</i>	<i>vy'api</i> → <i>γ'api</i>

b. Mario (3;03,01)

-TT: 3 out of 5 target	#TT: 2 out of 5 target
<i>pof't'i</i> → <i>pof't'i</i>	<i>ft'ipo</i> → <i>ft'ipo</i>
<i>kax't'i</i> → <i>tax't'i</i>	<i>xt'ika</i> → <i>xt'ipa</i>
<i>tovð'i</i> → <i>oð'i</i>	<i>vð'ito</i> → <i>v'ito</i>
<i>pivy'a</i> → <i>tivy'a</i>	<i>γð'oki</i> → <i>vð'oki</i>
<i>kiyð'o</i> → <i>iy'o</i>	<i>vy'api</i> → <i>x'api</i>

<sup>5</sup> In the cases of children that performed better at initial TT, the difference between the word initial condition and the word medial condition is consistently small: either one response difference (1-0, 2-1, 3-2, 4-3, 5-4) or maximum two responses difference (2-0) (see table 2).

c. Manouela (2;11,19)

-TT: 1 out of 5 target

*kaxt'i* → *ixt'i*

*pof't'i* → *xut'i*

*tovð'i* → *tuvl'i*

*kiyð'o* → *tliy'o*

*pivy'a* → *fij'a*

#TT: 0 out of 5 target

*ft'ipo* → *p'ipo*

*xt'ika* → *p'ika*

*vð'ito* → *θ'ito*

*γð'oki* → *kl'oki*

*vγ'api* → *k'api*

In order to test the difference between the two sectors, a one-variable chi-square test was performed. The  $\chi^2$  value of 11.3 DF=1 had an associated probability value of  $p=0.001$ . We can thus conclude that there is a statistically significant difference between the two sectors.

Moreover, coding was repeated using different criteria. Specifically, our original coding protocol defined as correct only those responses that involve a consonant cluster that is identical to the target one. According to the alternative criteria any responses that involve a TT (obstruent-obstruent) cluster are coded as correct, even if the cluster is not the target one. The reason for implementing this coding criterion is that such responses may be taken as an indication that the child can produce the relevant structure, even if s/he is unable to produce the segmental content of the specific cluster (for an example of a child language study that analyses production data under two different sets of criteria, see Jongstra (2003)). Some examples of such responses are given below.

28. a. #TT clusters

*xt'ika* → *ft'ika* (Mirto 3;00)

*ft'ipo* → *xt'ipo* (Zoi, 4;02,17)

*γð'oki* → *vð'oki* (Nikos 4;03,17)

*vð'ito* → *γð'ito* (Chrysa 4;00,03)

b. -TT clusters

*kaxt'i* → *kaft'i* (Vasiliki 3;10,15)

*tovð'i* → *toyð'i* (Chrysa 4;00,03)

*kivɔ̌'o* → *kivɔ̌'o* (Argiro 4;01,17)

*kaxt'i* → *kapt'i* (Manolios 4;00,12)

Following the alternative criteria, responses were coded as correct versus non-correct (see appendix). In both conditions there was an increase of responses coded as correct of about 10 percent (10.5% in word initial and 11.8% in word medial condition). Figure 6 contains the percentages of correct responses in the two conditions.

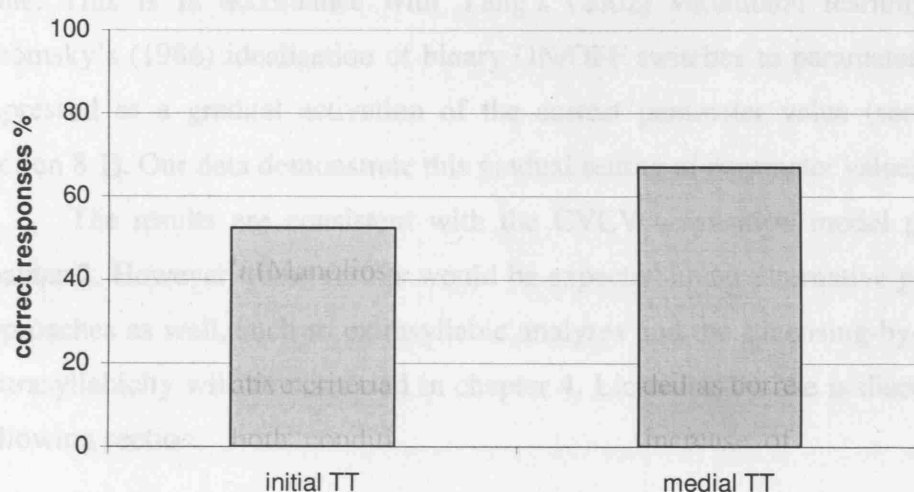


Fig. 6 Percentage of correct responses for word initial versus word medial TT clusters for all children combined, according to alternative criteria

The use of alternative criteria did not alter the relationship between the two conditions. As before, children's performance in the word initial condition was lower than in the word medial condition. A chi-square test had a  $\chi^2$  value of 13.040, with an associated probability of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. We can therefore conclude that there is a significant association between position and performance. Under the alternative coding criteria, too, children's performance was better in word medial position.

## **2.5 Analysis**

### **2.5.1 Testing the experimental hypothesis**

The results are consistent with the experimental hypothesis, namely that word initial TT is acquired after word medial TT. Children performed significantly better at word medial TT, showing that acquisition of word medial TT precedes that of word initial TT.

As expected, data were variable rather than categorical. As seen in Table 3, a child was likely to be able to produce some – or most – word medial TT clusters, but not necessarily all of them, and some word initial TT clusters, but not necessarily none. This is in accordance with Yang's (2002) variational learning, whereby Chomsky's (1986) idealisation of binary ON/OFF switches to parameter setting are expressed as a gradual activation of the correct parameter value (see chapter 2, section 8.1). Our data demonstrate this gradual setting of parameter values.

The results are consistent with the CVCV acquisition model presented in chapter 2. However, these results would be expected under alternative phonological approaches as well, such as extrasyllabic analyses and the Licensing-by-cue theory. Extrasyllabicity will be discussed in chapter 4. Licensing-by-cue is discussed in the following section.

### **2.5.2 Licensing by cue**

According to the Licensing-by-cue model (Steriade 1997), a contrast is better able to occur in a particular position the more easily recoverable its acoustic cues are in that position. The likelihood that a contrast will occur in a specific context depends on the cues that are available in that context (for an overview of cues and their perceptibility see Wright (2004)).

Extending this to first language acquisition, the prediction is that children will master the production of segments that are more perceptible in a particular context before they master the production of those that are less perceptible in that context (Vanderweide 2005a, 2005b). Vanderweide claims that consonants that have more or stronger acoustic cues to their place, manner and voicing in that position will be acquired earlier.

Crucially for our purposes, children are expected to acquire a segment in contexts supporting greater perceptibility before acquiring that particular segment in

less perceptible contexts (Vanderweide 2005a, 2005b). An example of this is the following perceptibility scale for prevocalic obstruents (from Vanderweide (2005a)).

## 29. Perceptibility scale for obstruents before different classes of segments

$\_V > \_S > \_O$	V vowel
	S sonorant consonant
	O obstruent
	> more perceptible than

An obstruent is more perceptible before a vowel than before a sonorant consonant because the acoustic cue in the former case is stronger. Formant transitions to a vowel are more robust due to greater amplitude in the vowels' formant structure when compared to sonorants. At the same time, an obstruent is more perceptible before either a vowel or a sonorant than before another obstruent because the formant transitions are potentially absent in the latter context, especially before a stop. Vanderweide (2005a) claims that acquisition follows the perceptibility scale shown in 29. Children tend to acquire obstruents in a prevocalic position first, then in a pre-sonorant position and finally in a pre-obstruent position.

An important issue when comparing word medial and word initial consonants (or clusters, as we are doing) is a comparison of the relevant cues for consonants in postvocalic position (V\_) to those for consonants in word initial position (#\_). Following Steriade (1997), who equates the end of a word with the end of an utterance, I equate the beginning of a word with the beginning of an utterance. I thus compare cues for consonants in a postvocalic position to those for consonants in a post-silence position (but see discussion in section 3.5). Consonants in postvocalic positions enjoy cues in the form of formant transitions from the preceding vowel. These cues are absent in the case of post-silence consonants.<sup>6</sup>

As far as TT clusters are concerned, the following perceptibility scale can be constructed regarding the word initial and word medial position.

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<sup>6</sup> It has been argued that these cues (cues from a vowel that precedes the consonant) are weaker (less perceptible) than the cues into a vowel that follows the consonant (Wright 2004).

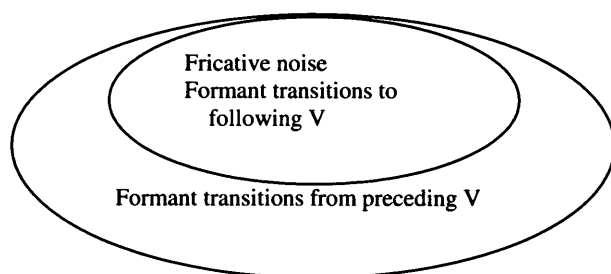
### 30. Perceptibility scale for TT clusters in different positions

V\_V > #\_V

> more perceptible than

A TT cluster is more perceptible in word medial than in word initial position because there are more cues for the cluster in word medial position. Specifically, for fricative-fricative clusters, the main cues in word medial position are frication noise, formant transitions to the following vowel and formant transitions from the preceding vowel. Frication noise is a cue for manner, while the spectrum of the frication noise and formant transitions are place cues. In word initial position, frication noise and formant transitions to the following vowel are still present, but there are no formant transitions before the cluster, since there is no vowel preceding. In terms of sets, the cues in word initial position are a proper subset of the cues in word medial position.

### 31. A subset relation: Cues for fricative-fricative clusters in word initial and word medial position

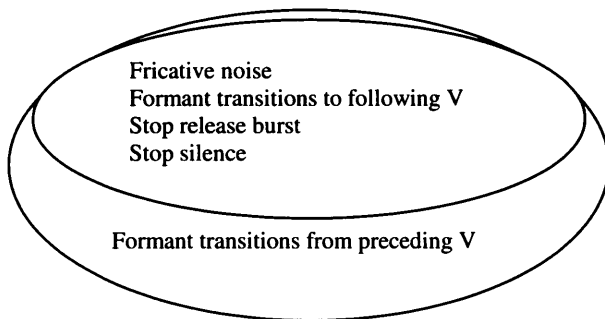


Small oval: cues in word initial position

Large oval: cues in word medial position

A subset relation is also found in the case of fricative-stop clusters in word initial and word medial position. There is an extra place cue (stop release burst) and an extra manner cue (attenuation of signal –silence) in both contexts.

32. A subset relation: Cues for fricative-stop clusters in word initial and word medial position



Small oval: cues in word initial position

Large oval: cues in word medial position

As a result of this difference in perceptibility, earlier acquisition of TR clusters in word medial position is expected.

We therefore encounter a situation where two phonological models, CVCV and Licensing-by-cue, can both account for a particular set of data. In order to test the empirical coverage of these theories we need to find a domain where the two rival theories make different predictions.

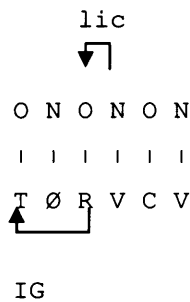
### 3 The TR experiment

#### 3.1 The prediction

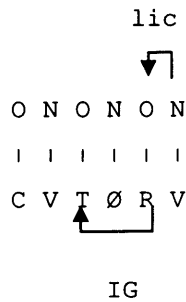
In this section I examine the order of acquisition of TR clusters in word initial versus word medial position.

According to the CVCV model presented in chapter 2, we expect to find no difference in the acquisition of word medial and word initial TR. The reason is that the requirements for the existence of TR are the same in both positions. Specifically, a marked setting for the Nuclei+/-license parameter is the necessary and sufficient condition in both cases. The relevant structures are given schematically below.

### 33. Word initial position



### Word medial position



In both word initial and word medial position the liquid needs to be licensed by the following vowel in order to be able to dispense infrasegmental government. The creation of a domain of infrasegmental government ensures that the Empty Category Principle with regard to the empty nucleus between the two consonants is satisfied. Failure of licensing to apply would result in a collapse of the cluster structure due to a potential violation of the ECP.

A consequence of the claim that there is no difference in the requirements for word initial and word medial TR is that we expect to find no imbalance in the acquisition of TR in the two positions. Unlike the prediction regarding TT, we expect no difference in the acquisition of word initial versus word medial TR.

This prediction is not unique to CVCV. The same acquisition order would be expected under any syllabic theory (sonority-based or complexity-based) that assumes branching structures. Branching onsets have identical structures in both word initial and word medial position.

### 34. a. Word initial TR



### b. Word medial TR



*tr'eno* 'train' (Greek)

*p'etra* 'stone' (Greek)



Consequently, no difference in their acquisition of TR in the two positions would be expected (for a comparison of CVCV with other syllabic theories see chapter 4).

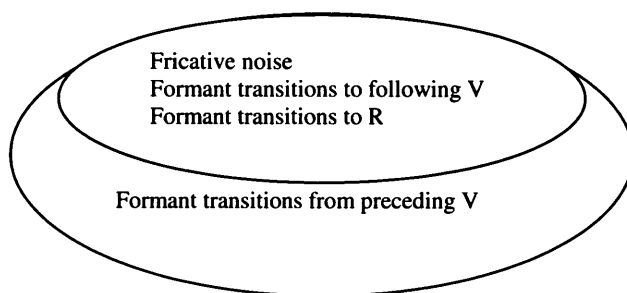
However, in this case the prediction of the Licensing-by-cue model would be different. A perceptibility scale for TR clusters would be as follows.

### 35. Perceptibility scale for TR clusters

$$V\_V > \#\_V$$

A TR cluster is more perceptible in word medial than in word initial position because there are more cues for the cluster in word medial position. Specifically, for fricative-sonorant clusters, the main cues in word medial position are frication noise, formant transitions to the sonorant and to the following vowel and formant transitions from the preceding vowel. Frication noise is a cue for manner, while the spectrum of the frication noise and formant transitions are place cues. In word initial position there are no formant transitions from a preceding vowel. In terms of sets, the cues in word initial position are a proper subset of the cues in word medial position.

### 36. A subset relation: Cues for fricative-sonorant clusters in word initial and word medial position

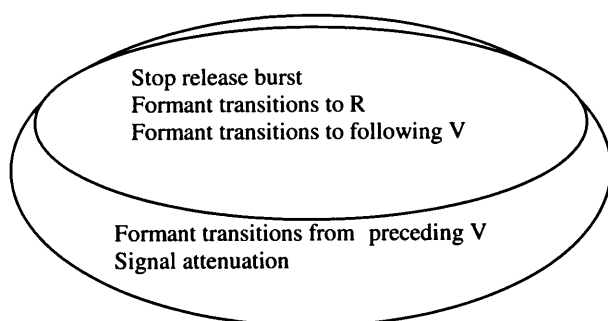


Small oval: cues in word initial position

Large oval: cues in word medial position

The same relation is found in the case of stop-sonorant clusters. In addition to the cues mentioned above, there is an extra manner cue in word medial position (attenuation of signal –silence) (but see section 3.5 for connected speech). The cues also include an extra place cue (stop release burst) in both contexts.

37. A subset relation: Cues for stop-sonorant clusters in word initial and word medial position



Small oval: cues in word initial position

Large oval: cues in word medial position

This difference in perceptibility, following Vanderweide's (2005a) model predicts that children should acquire TR clusters word medially before they acquire them word initially.

### 3.2 Goal of the experiment

The goal of this experiment is to test whether Greek children acquire word initial TR clusters after the corresponding word medial ones. In order to test this, I examined children's production of these clusters.

According to the experimental hypothesis ( $H_1$ ) children will perform better at word medial clusters than at word initial ones. The null hypothesis ( $H_0$ ) is that there will be no difference in performance.

### 3.3 Methods and materials

Subjects, methodology and procedure were the same as in the previous experiment (sections 3.3.1, 3.3.2 and 3.3.4 respectively). A non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children. Children were asked to repeat words that contained the target cluster and their responses were recorded and transcribed.

There were two conditions; the first condition involved words with TR clusters in initial position, and the second condition involved words with the same clusters in

medial position. The clusters tested had either a stop or a fricative as a first member, and either *r* or *l* as a second member. Specifically, the following clusters were tested:

38. *tr*, *kl*, *fl*, *xr*, *vr*

These clusters are allowed in Greek both word initially and word medially. Some examples follow.

39. a Word initial position

*tr*<sup>1</sup>*eno* ‘train’

*kl*<sup>1</sup>*ino* ‘close’ 1<sup>ST</sup> SG

*fl*<sup>1</sup>*uði* ‘(fruit) skin’

*xr*<sup>1</sup>*onos* ‘year’

*vr*<sup>1</sup>*isko* ‘find’ 1<sup>ST</sup> SG

b. Word medial position

*p*<sup>1</sup>*etra* ‘stone’

*k*<sup>1</sup>*ukla* ‘doll’

*tifl*<sup>1</sup>*os* ‘blind’

*m*<sup>1</sup>*exri* ‘until’

*nevri*<sup>1</sup>*azo* ‘get angry’ 1<sup>ST</sup> SG

The non-words were designed following the same principles as for the previous experiment (see section 3.3.3), forming feminine or neuter nouns. All words were bisyllabic, with a voiceless stop as an onset for the non target syllable; *p*, *t* or *k*. The cluster initial condition consisted of the following words:

40. *tr*<sup>1</sup>*ika*, *kl*<sup>1</sup>*ito*, *fl*<sup>1</sup>*api*, *xr*<sup>1</sup>*oki*<sup>7</sup>, *vr*<sup>1</sup>*ipo*.

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<sup>7</sup> See footnote 2 for velar fronting. Moreover, one of the nurseries was in an area (Iraklio) where *l* tends to be palatalised before *i*. For example, *tokl*<sup>1</sup>*i* would be pronounced [tok<sup>1</sup>*ʲ**i*]. Indeed, some children exhibited palatalisation of *l*. However, that does not affect our experiment in any crucial way.

The words of the second condition were formed by reversing the syllable order, giving the words in 41.

41. *katr'i, tokl'i, pifl'a, kixr'o, povr'i*.

For uniformity, the target cluster always preceded the stressed vowel.

Transcription was done in the same way as for the TT experiment, and coding followed the same principles (see section 3.3.5).

### 3.4 Results

#### 3.4.1 General results

The categories used for coding were the same as those used for the TT experiment. Table 4 shows the categories with an example for each, followed by some more examples of responses in the word initial condition (42-47).

Table 4. Categories used in coding with examples of corresponding responses

Code	Stimulus	Response
Correct	<i>fl'api</i>	<i>fl'api</i>
Drops 1 <sup>st</sup>	<i>kl'ito</i>	<i>l'ito</i>
Drops 2 <sup>nd</sup>	<i>kl'ito</i>	<i>k'ito</i>
Other single	<i>fl'api</i>	<i>t'api</i>
Change one	<i>fl'api</i>	<i>xl'api</i>
Other	<i>tr'ika</i>	<i>tor'ika</i>

#### 42. Correct

*fl'api* → *fl'api* (Manthos 3;00,19)

*xro'ki* → *xro'ki* (Agelos 3;04,12)

*vr'ipo* → *vr'ipo* (Fenia 3;01,04)

#### 43. Drops 1<sup>st</sup>

*fl'api* → *l'api* (Giota 3;04,15)

*fl'api* → *l'api* (Emanouela 4;11,21)

*kl'ito* → *l'ito* (Mairi 4;04,01)

44. Drops 2<sup>nd</sup>

*kl'ito* → *k'ito* (Lena 2;10,28)

*vr'ipo* → *v'ipo* (Maraki 3;05,03)

*xro'ki* → *xo'ki* (Mirto 3;00)

45. Other single

*fl'api* → *t'api* (Emanouil 2;10,20)

*vr'ipo* → *ð'ipo* (Mirto 3;00)

*kixr'o* → *tik'o* (Kali 3;00,03)

46. Change one

*fl'api* → *xl'api* (Eirini 3;10,25)

*kl'ito* → *pl'ito* (Nikos 4;03,17)

*vr'ipo* → *pr'ipo* (Giota 3;04,15)

47. Other

*tr'ika* → *tor'ika* (Stamatis 3;08,03)

*kl'ito* → *xr'iko* (Maraki 3;05,03)

*vr'ipo* → *yl'ipo* (Manolio 3;06,17)

The results for word initial TR are given in Figure 7. In the appendix, I give the complete results for both word initial and word medial positions, including raw numbers and percentages.

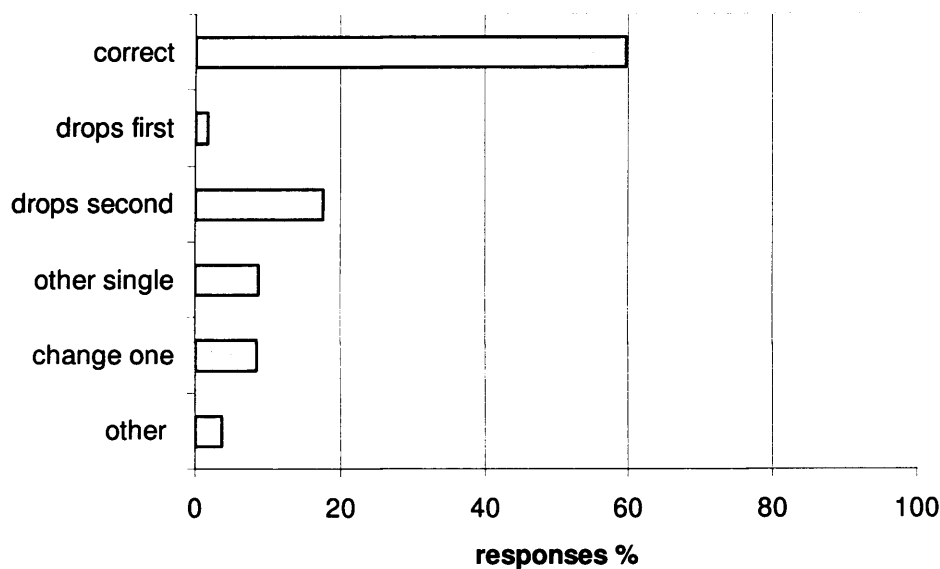


Fig. 7 Word initial TR clusters (n=295), percentage of responses by category for all children combined

Target responses were given almost 60 percent of the time. The most common non-target response was dropping of the second member of the cluster while the first member was dropped very rarely.

In 48-53 I list some examples of children's performance in the word medial condition.

#### 48. Correct

*kixr'o* → *kixr'o* (Kaliopi 3;11,11)

*povr'i* → *plovri* (Pantelis 3;01,29)

*tokl'i* → *tokl'i* (Fenia 3;01,04)

#### 49. Drops 1<sup>st</sup>

*tokl'i* → *li* (Manouela 2;11,19)

#### 50. Drops 2<sup>nd</sup>

*povr'i* → *puv'i* (Nikolas 2;10,29)

*kixr'o* → *kix'o* (Manolio 3;06,17)

*katr'i* → *kat'i* (Despina 3;06,29)

51. Other single

*katr'i* → *kaθ'i* (Maraki 3;05,03)

*kixr'o* → *tik'o* (Kali 3;00,03)

*katr'i* → *kaf'i* (Manolio3;06,17)

52. Change one

*kixr'o* → *kixt'o* (Argiroula 3;04,01)

*katr'i* → *kaxr'i* (Kostantina 3;11,11)

*piɸl'a* → *pixl'a* (Kostantinos 2;11,17)

53. Other

*katr'i* → *kart'i* (Zoi 4;02,17)

*kixr'o* → *kift'o* (Mirto 3;0)

*kixr'o* → *kirx'o* (Nikos 4;03,17)

The results for word medial TR are presented in figure 8 below.

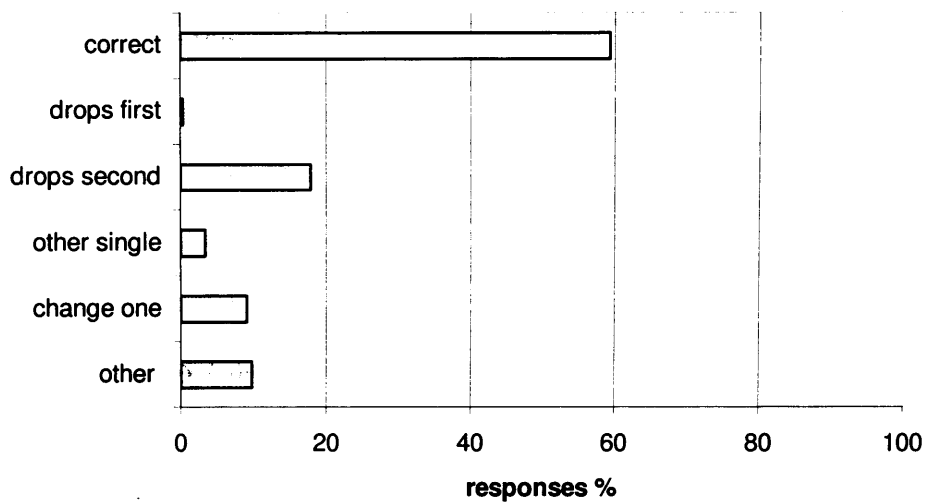


Fig. 8. Word medial TR clusters (n=295), percentage of responses by category for all children combined

The results in the word medial condition are not very different from those in the word initial condition. The percentage of correct responses is again very high, ‘drops second’ was the most popular non-target response, while the first consonant was dropped only once.

A one variable chi-square test was performed to test whether the two consonants were dropped equally often in the word initial condition. A  $\chi^2$  value of 38.754, DF=1, had an associated probability value of 0.001. We can conclude that the difference between dropping of the first consonant and dropping of the second consonant is statistically significant. Figure 7 shows that the second consonant was dropped more than the first one. As for the word medial condition, a  $\chi^2$  value of 50.074, DF=1, had an associated probability value of p=001. We can thus conclude that the difference between dropping of the first consonant and dropping of the second consonant is statistically significant. Figure 8 shows that the second consonant was dropped more often.

### 3.4.2 #TR versus -TR

In a comparison of the performance in the two positions, there seems to be no difference between the two positions. There were 176 target responses (out of 295 trials) for the word initial condition, and 175 target responses (out of 295 trials) for the word medial condition. Figure 9 shows the corresponding percentages in the two conditions.

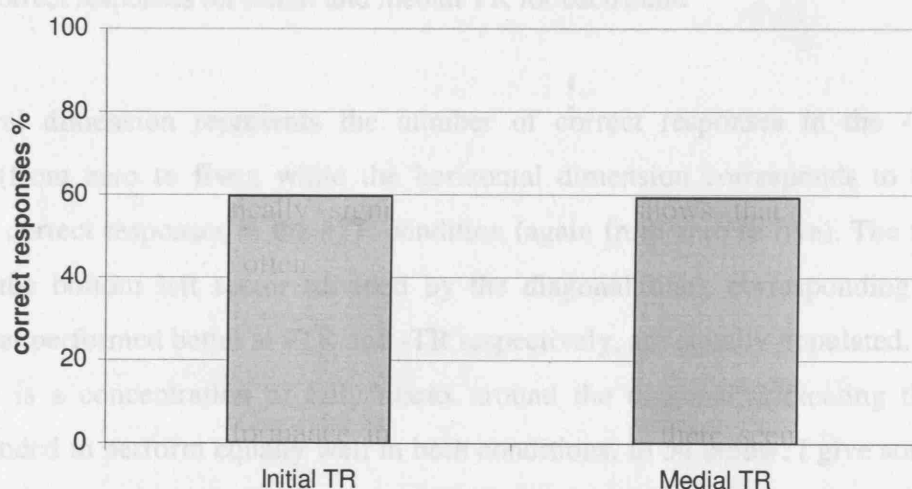


Fig. 9 Percentage of correct responses for word initial versus word medial TR clusters for all children combined



A chi-square test was carried out to discover whether there was a significant relationship between position and performance (number of correct responses). The  $\chi^2$  value of 0.007 had an associated probability value of  $p < 0.933$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. No significant association between position and performance was found. Children's performance was not found to be better in either position.

In addition, the table showing the number of correct responses for each child for both conditions (#TR and -TR) is given below.

		#TR					
-TR		0	1	2	3	4	5
	0	/// //					
	1	//	///		//		/
	2	/		//	///	/	/
	3			//	/	/// /	/
	4	/		///	//	/// /	/// /
	5			/	//	///	/// //

Table 5: Correct responses for initial and medial TR for each child

The vertical dimension represents the number of correct responses in the -TR condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the #TR condition (again from zero to five). The top right and the bottom left sector (divided by the diagonal line), corresponding to children that performed better at #TR and -TR respectively, are equally populated.

There is a concentration of tally marks around the diagonal, indicating that children tended to perform equally well in both conditions. In 54 below, I give some examples of children's performance, illustrating this tendency. Stavros (54a) performed adult-like in both conditions, while Lena (54b) performed poorly in both

conditions. Finally, Mario's performance (54c) was better than Lena's, but the child was still having problems with TR clusters in both positions.

54. a. Stavros (3;11,24)

-TR: 5 out of 5 target	#TR: 5 out of 5 target
<i>katr'i</i> → <i>katr'i</i>	<i>tr'ika</i> → <i>tr'ika</i>
<i>tokl'i</i> → <i>tokl'i</i>	<i>kl'ito</i> → <i>kl'ito</i>
<i>piɸl'a</i> → <i>piɸl'a</i>	<i>ɸl'api</i> → <i>ɸl'api</i>
<i>kixr'o</i> → <i>kixr'o</i>	<i>xr'oki</i> → <i>xr'oki</i>
<i>povr'i</i> → <i>povr'i</i>	<i>vr'ipo</i> → <i>vr'ipo</i>

b. Lena (2;10,28)

-TR: 1 out of 5 target	#TR: 0 out of 5 target
<i>tokl'i</i> → <i>tokl'i</i>	<i>tr'ika</i> → <i>t'ika</i>
<i>katr'i</i> → <i>kat'i</i>	<i>kl'ito</i> → <i>c'ito</i>
<i>piɸl'a</i> → <i>piɸɸ'a</i>	<i>ɸl'api</i> → <i>ɸ'api</i>
<i>kixr'o</i> → <i>kix'o</i>	<i>xr'oki</i> → <i>x'oki</i>
<i>povr'i</i> → <i>pov'i</i>	<i>vr'ipo</i> → <i>v'ipo</i>

c. Mario (3;03,01)

-TR: 3 out of 5 target	#TR: 2 out of 5 target
<i>katr'i</i> → <i>katr'i</i>	<i>tr'ika</i> → <i>tr'ika</i>
<i>tokl'i</i> → <i>kl'i</i>	<i>kl'ito</i> → <i>kl'ito</i>
<i>piɸl'a</i> → <i>ɸl'a</i>	<i>ɸl'api</i> → <i>vɸ'api</i>
<i>kixr'o</i> → <i>ixk'o</i>	<i>xr'oki</i> → <i>'oti</i>
<i>povr'i</i> → <i>toɸ'i</i>	<i>vr'ipo</i> → <i>v'ipo</i>

A one-variable chi-square test that was carried out to test the difference between the two sectors in table 5 had a  $\chi^2$  value of 0.111, with an associated probability value of  $p=0.739$ ,  $DF=1$ . There was no statistically significant difference between the two sectors.

Moreover, coding was repeated using the alternative criterion discussed in section 2.4.3. Specifically, contrary to the original coding protocol, which demanded that only responses that contain the target cluster be coded as correct, any responses that involve a cluster belonging to the same category as the target cluster (obstruent-liquid) cluster are coded as correct, even if the cluster is not the target one. In 55 I give some examples of such responses.

55. a. #TR clusters

*fl'api* → *xl'api* (Kostantinos 2;11,17)

*fl'api* → *θl'api* (Giorgos 4;00,14)

*kl'ito* → *pl'iko* (Dimitra 3;00,03)

*tr'ika* → *kr'ika* (Kostantina 3;11,11)

b. -TR clusters

*katr'i* → *kaxr'i* (Kostantina 3;11,11)

*katr'i* → *kapr'i* (Agelos 3;04,12)

*povr'i* → *klukl'i* (Manouela 2;11,19)

*tokl'i* → *topl'i* (Vagelio 2;10,07)

Responses were coded as correct versus non-correct, following the alternative criteria. There was an increase of responses coded as correct of 9.5% in word initial and 7.1% in word medial condition. Figure 10 contains the percentages of correct responses in the two conditions (for raw numbers see appendix).

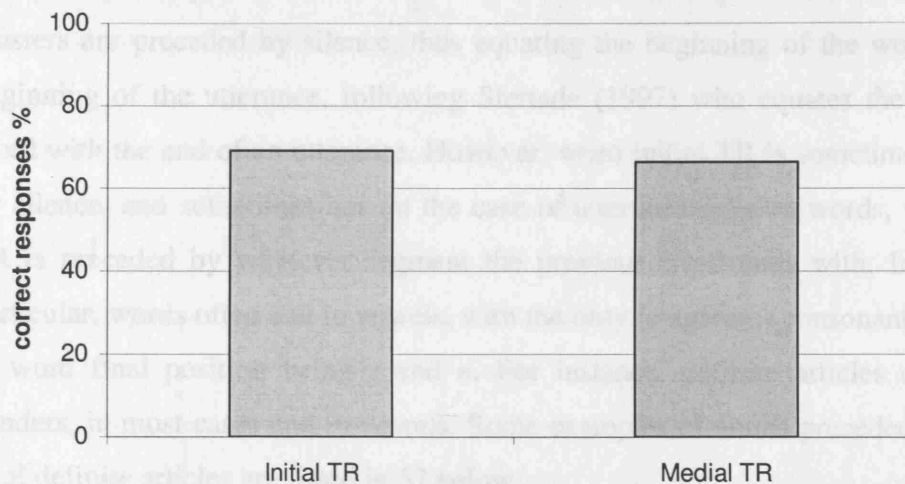


Fig. 10 Percentage of correct responses for word initial versus word medial TR clusters for all children combined, according to alternative criteria

As before, children's performance was about the same in both conditions. A chi-square test had a  $\chi^2$  value of 0.497, with an associated probability of  $p=0.481$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. No significant association between position and performance was found. Children's performance was not found to be better in either condition.

### 3.5 Analysis

The results revealed no difference between word initial and word medial position with regard to TR acquisition. These results are not consistent with the experimental hypothesis, according to which word medial TR is acquired before word initial TR. Such a difference was predicted to exist according to the Licensing-by-cue model, following the relevant perceptibility scale in 35.

Seeing that the Licensing-by-cue prediction was not borne out, I examine a possible way of amending the perceptibility scale in 35, repeated here for convenience, in order to accommodate the findings.

#### 56. Perceptibility scale for TR clusters

$$V\_V > \#\_V$$

The perceptibility scale was constructed under the assumption that word initial TR clusters are preceded by silence, thus equating the beginning of the word with the beginning of the utterance, following Steriade (1997) who equates the end of the word with the end of an utterance. However, word initial TR is sometimes preceded by silence, and sometimes not: in the case of utterance-internal words, word initial TR is preceded by whatever segment the previous word ends with. In Greek, in particular, words often end in vowels, with the only (singleton) consonants permitted in word final position being *s* and *n*. For instance, definite articles of all three genders, in most cases end in vowels. Some examples of nouns preceded by vowel-final definite articles are listed in 57 below.

57. a. *o*                      *kapitalist<sup>1</sup>is*  
           the.M.SG.NOM capitalist.M.SG.NOM  
           ‘the capitalist’
- b. *i*                        *katastrof<sup>1</sup>i*  
           the.F.SG.NOM destruction.F.SG.NOM  
           ‘the destruction’
- c. *tu*                      *periv<sup>1</sup>alondos*  
           the.N.SG.GEN environment.N.SG.GEN  
           ‘(of) the environment’
- d. *ta*                      *peðj<sup>1</sup>a*  
           the.N.PL.NOM children.N.PL.NOM  
           ‘the children’

In connected speech, there are approach cues originating from the final vowel (e.g. *u* in 57c) into the word initial consonant (*p* in 57c). Given the high frequency of such cases in Greek, it would be conceivable to construct an alternative perceptibility scale, following the assumption that word initial TR clusters are intervocalic, just

like their word medial counterparts. In the alternative perceptibility scale, word initial and word medial TR are equally perceptible<sup>8</sup>.

58. Alternative perceptibility scale for TR clusters in Greek

$$V\_V = \#\_V$$

The alternative perceptibility scale in 58 would predict simultaneous acquisition of #TR and –TR, since the two are equally perceptible. This prediction would be consistent with our experimental results.

The alternative perceptibility scale would thus capture the results of the TR experiment, but it would fail to capture the results of the TT experiment in section 2. The reason is that, for consistency, we would be forced to construct a similar perceptibility scale for TT clusters. The original perceptibility scale for TT clusters was made by assuming that word initial TT clusters are preceded by silence.

59. Perceptibility scale for TT clusters

$$V\_V > \#\_V$$

Word initial TT in Greek, just like word initial TR, is often preceded by a vowel. In the alternative perceptibility scale, word initial and word medial TT would be equally perceptible, following the reasoning that word initial TT is (often) intervocalic, like its word medial counterpart.

60. Alternative perceptibility scale for TT clusters

$$V\_V = \#\_V$$

---

<sup>8</sup> There is yet another alternative, which would take into account frequency effects: word medial TR is always postvocalic, while word initial TR is sometimes post-vocalic, sometimes post-consonantal, and sometimes post-silence. This alternative would make essentially the same predictions as the first perceptibility scale (35): children would hear word medial TR in highly perceptible contexts more often than word initial TR (the latter sometimes being in the highly perceptible post-vocalic context, and sometimes in the less perceptible post-consonantal or post-silence contexts) and would thus be expected to acquire word medial TR before its word initial counterpart.

The alternative perceptibility scale for TT would predict no difference in the acquisition of word initial TT and word medial TT. This prediction would be falsified by the results of the relevant experiment in section 2, which showed earlier acquisition of word medial TT.

The situation is thus as follows: under either perceptibility scale, the Licensing-by-cue model would make the right prediction about one of the two cluster types and the wrong prediction about the other cluster type. If the original perceptibility scale is adopted, the results of the TT experiment can be covered, but not the results of the TR experiment. Conversely, if the alternative perceptibility scale is adopted, the results of the TR experiment can be covered but those of the TT experiment falsify the model. Note that we are forced to adopt the same perceptibility scale for the two cluster types. For consistency, if we assume that TR is post-silence, we have to do the same for TT, and if we assume that TR is post-vocalic we have to assume the same for TT. Also, note that the original perceptibility scale for the two clusters reflects the same distance in perceptibility between word initial and word medial TT as that between word medial and initial TR. Approach cues from a preceding vowel into T are exactly the same in both TR and TT clusters, so presence (in word medial position) versus absence (in word initial position) of such cues would create exactly the same distance in perceptibility between word initial and word medial position for both TT and TR. Consequently, if we find a difference in the acquisition of word medial and word initial TT, we would expect to find a corresponding difference in the acquisition of word medial and word medial TR.

In sum, the combined results of the two experiments are incompatible with the Licensing-by-cue acquisition model, while they are compatible with the CVCV acquisition model. According to the CVCV account, word medial TT is acquired before word initial TT, because the marked settings required for the former are a subset of those required for the latter. On the other hand, there is no difference in the acquisition of word initial and word medial TR, because they have the same requirements.

## 4 Conclusion

The results of the two experiments were consistent with the predictions of the CVCV acquisition model. Of particular importance are new findings regarding the order of acquisition of clusters of non-rising sonority. Moreover, I provided extra experimental evidence from the acquisition of clusters of rising sonority in support of the CVCV model and against a possible rival acquisition model. The main findings are summarised below (the right-hand column refers to the section in which the findings were reported).

61. Findings	Section
-TT > #TT	2
-TR = #TR	3

> better performance  
= similar performance



## CHAPTER 4. sT CLUSTERS

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### 1 Introduction

A cluster type that is notoriously difficult for phonologists as well as for acquisitionists is s+consonant. In this chapter, I test predictions of the CVCV model with regard to the acquisition of s+obstruent<sup>1</sup> clusters (henceforth sT), with a series of experiments.

The comparisons made are the following: firstly, word initial sT is compared to (other) word initial TT clusters (section 2), and then the two cluster types (sT and TT) are compared to word initial TR (section 3). Then word initial sT is examined against word medial sT (section 4) and then the latter is compared to word medial TR (section 5). Finally, section 6 examines the acquisition of licensing (TR) clusters compared to that of government clusters (TT, sT, RT) and the claim of an implicational universal regarding complex onsets and codas is examined.

### 2 #sT versus #TT

#### 2.1 The prediction

##### 2.1.1 CVCV

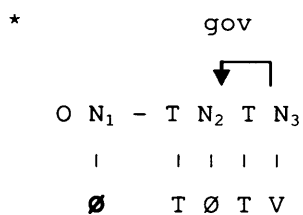
s+obstruent clusters (henceforth sT) present a problem for CVCV theory. They seem to disobey the dichotomy created by the Initial ON parameter. In order to make this clear, I shall briefly remind the reader of the function of the parameter.

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<sup>1</sup> The case of sR clusters, which is equally problematic in adult and child language, is not examined here (for an overview the reader is referred to Barlow (2001)). For sR in acquisition see also Barlow (Barlow 1997), Kirk (2005), Jonstra (2003), Vanderweide (2005) amongst others.

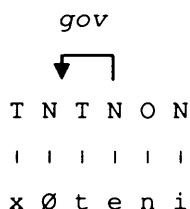
There is a parameter according to which some languages have an ON pair at the beginning of the word, while others do not. Languages that have this ON pair (e.g. English) cannot have word initial obstruent-obstruent clusters, because the empty nucleus of the pair would not be governed and the ECP would be violated. In example 1,  $N_1$  is not governed (recall that governed nuclei –  $N_2$  in our example – cannot govern) rendering the structure ill-formed.

### 1. Initial TT in English: ill formed



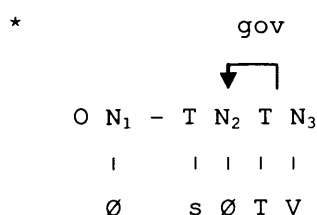
According to the dichotomy created by the binary parameter, languages that do not have this ON pair (e.g. Greek) can freely have TT clusters word initially. In example 2, unlike in example 1, there is no ungoverned empty nucleus.

### 2. Initial TT in Greek: well-formed



Word initial sT clusters constitute a counterexample to the theory. Since sT is a type of TT (obstruent-obstruent) cluster, the theory predicts that sT should not be allowed word initially in languages like English, which do not have any (other) TT clusters.

### 3. Initial sT in English predicted to be ill formed

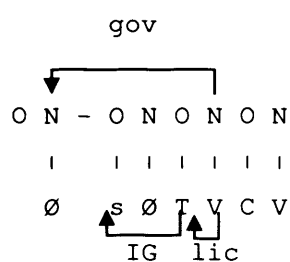


In example 3, the structure assumed by CVCV for English involves an ungoverned empty nucleus in the case of initial sT clusters, which should therefore be ill-formed. However, word initial sT clusters are allowed in English, as well as other languages that allow no (other) word initial TT clusters (e.g. Italian).

Faced with this counterexample to the dichotomy expressed in CVCV, either we abandon the theory or we make an auxiliary hypothesis to deal with the counterexample.

A possible amendment to the theory might be that sT clusters form a domain of infrasegmental government, like TR clusters, and thus require licensing rather than government, for their formation (see chapter 2, section 4.2). Such an assumption would account for the existence of word initial sT clusters in a language like English: the cluster is formed by licensing, while the initial empty nucleus is governed by the first full nucleus (4).

### 4. Initial sT in English: possible structure



However, the structure in 4 cannot be correct. Apart from possible theory-internal reasons regarding requirements on the internal composition of segments in Infrasegmental Government (see chapter 2, section 4.2), such a decision would mean that sT is a type of TR cluster, while there is evidence that sT does not pattern with TR. For example, a well-known case is the distribution of the singular masculine

definite article in Italian (Davis 1990; Kaye 1992). Whilst the article has the form *il* before single consonants and TR clusters, before sT clusters it takes the form *lo*<sup>2</sup>.

5. a. Single consonant

*il topo* ‘the mouse’

*il faro* ‘the lighthouse’

*il sole* ‘the sun’

b. TR cluster

*il treno* ‘the train’

*il globo* ‘the globe’

*il frutteto* ‘the orchard’

c. sT cluster

*lo studente* ‘the student’

*lo scambio* ‘the exchange’

*lo sforzo* ‘the effort’

*lo spirito* ‘the spirit’

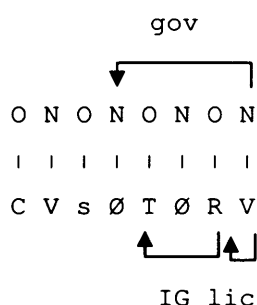
The situation is thus as follows: initial sT clusters are allowed in languages with or without initial TT clusters, but they are different from TR clusters.

A further problem for the structure in 4, which assumes that sT clusters are formed by licensing, is the existence of (word initial as well as word medial) sTR clusters. In these clusters, according to CVCV mechanisms, the TR part of the cluster will be formed by licensing, and therefore the only available force for the formation of the sT part of the cluster is government. Example 6 illustrates the structure of a word medial sTR cluster (ignoring, for simplicity, the word initial ON pair, which does not affect this structure).

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<sup>2</sup> Before vowels the article appears as *l*. For example: *l’arco* ‘the arch’, *l’elenco* ‘the list’. This *l*, according to Kaye et al (1990), is a syncopated form of *lo*.

## 6. sTR

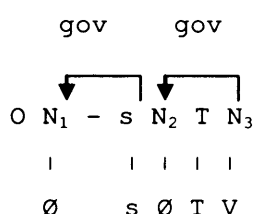


The existence of sTR clusters constitutes strong evidence against a licensing analysis of sT clusters, cancelling any attempt to make such an auxiliary hypothesis.

### 2.1.2 The proposal

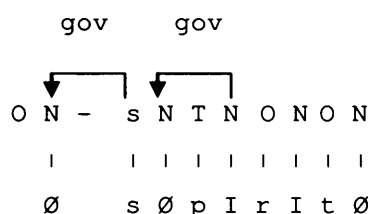
Recall that in terms of the Initial ON parameter, sT exists in grammars with either setting of the parameter, even though under the current formulation of the theory it should not exist when an Initial ON is present because the initial empty nucleus would be left ungoverned. In this section, I propose an auxiliary hypothesis that can deal with this problem. Specifically, I propose the auxiliary hypothesis that *s (in sT clusters) has the property of being able to govern the initial empty nucleus  $N_1$ .*

## 7. sT in English: auxiliary hypothesis: s governs $N_1$



In 7,  $N_2$ , the empty nucleus between s and T, is governed by the following full nucleus, while  $N_1$ , the initial empty nucleus, is governed by the s. For clarity, I illustrate the structure with an English word (ignoring the final empty nucleus, for simplicity).

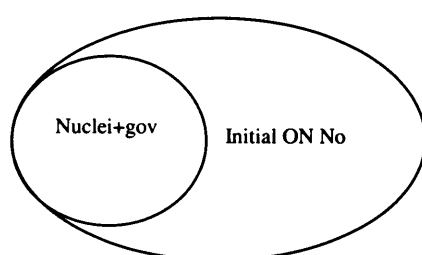
## 8. *spirit*



I propose this auxiliary hypothesis as a principle, not derived from anything in the theory. The question of whether this principle can be derived from something is a possible route of investigation, but another, equally interesting route of investigation is to examine the consequences of the auxiliary hypothesis. If the auxiliary hypothesis is found to enrich the theory by having falsifiable (but unfalsified) consequences independent of the facts it is designed to deal with, then we will have made progress.

Such falsifiable consequences can be found in first language acquisition. Specifically, the updated theory predicts that word initial sT clusters should be acquired before word initial TT clusters, in languages that have both. The reason is that the marked parameter settings required for word initial sT form a proper subset of the marked settings required for word initial TT. Specifically, sT requires one marked setting: Nuclei+govern. TT requires Nuclei+govern as well, plus an extra marked setting: initial ON No.

## 9. A subset relation



Small oval: conditions for word initial sT

Large oval: conditions for word initial TT

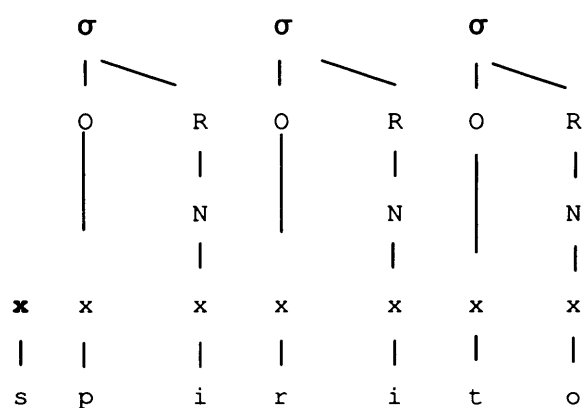
The cluster that requires the subset of marked settings, in this case sT, is expected to be acquired before the cluster that requires the superset of marked settings, in this case TT.

### 2.1.3 Other approaches

Word initial sT does not respect the Sonority Sequencing Generalisation (SSG, Clements (1990) see chapter 2), according to which sonority increases towards the syllable peak and decreases towards the edges. Initial sT breaks this generalisation, since the second member of the cluster has a lower (in the case of stops) or an equal (in the case of fricatives) sonority value when compared to the first member (s). This is the opposite of what the SSG dictates for onsets; the second member of the cluster should be of higher sonority.

Faced with this inconsistency, several researchers have opted for a syllabification algorithm that leaves the *s* outside the onset: the *s* is extrasyllabic<sup>3</sup> (e.g. Halle & Vergnaud (1980), Levin (1985), Steriade (1982)). An example of such a structure is given in 10 below.

#### 10. sT extrasyllabicity: Italian *sp'irito*

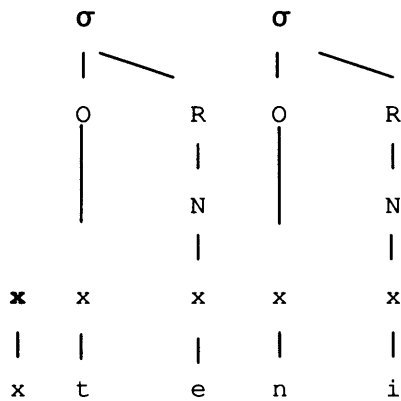


Later in derivation the *s* may be linked to a constituent via some kind of adjunction rule. The desired effect is thus attained: at the first stage, the SSG is not violated, since the *s* is not linked to the onset, while at the same time eventual integration to the syllabic structure is achieved.

<sup>3</sup> Other attempts include analysis of sT as a contour-complex segment (Selkirk (1982), Weijer (1993) cf. Scobbie (1997)) and the abandoning of the SSG as a universal principle (Cairns 1988).

The same, extrasyllabic structure, has been proposed for word initial TT clusters ( e.g. Rubach & Booij (1990), Steriade (1982)).

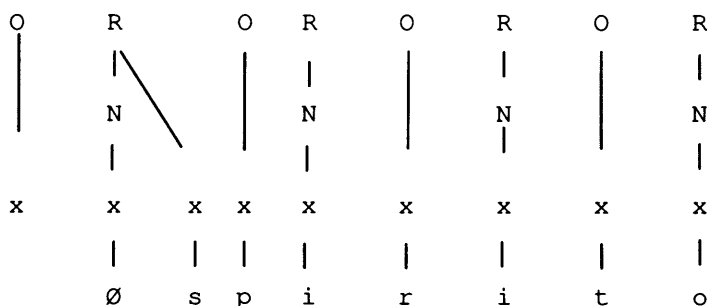
#### 11. TT extrasyllabicity: Greek *xt<sup>l</sup>eni*



These clusters, too, violate the SSG (as noted in chapter 1), and an identical phonological analysis for both sT and TT, such as extrasyllabicity, seems to be a sensible move.

However, extrasyllabicity has encountered severe criticism (see, for example, Scheer (2004)). Crucially for our purposes, extrasyllabicity fails to capture an important point: that sT clusters are attested in languages that have no other SSG violating clusters. This type of evidence led Kaye (1992) to argue that sT clusters are unique because of some special property of *s*. This property sets sT clusters apart from all others, and is responsible for all the peculiarities of sT. The nature of this property, Kaye claims, is not yet understood, but its existence has to be recognized. In Government Phonology, the framework developed in Kaye's paper, this property enables the *s* to 'magically' occupy a word-initial coda position. Kaye (1992) thus proposes an auxiliary hypothesis to deal with the misbehaving sT clusters.

#### 12. Word initial coda: Italian *spirito*





Moreover, Kaye et al (1990), suggest that (ancient) Greek word initial *pt/kt* clusters are of the same nature as sT. Such a suggestion contradicts the insight of the special nature of *s*. However, the fact that neither sT nor TT can be accommodated within the canonical syllabic structure of the framework lead Kaye et al (1990), to suggest that the two have the same structure (cf. Pagoni 1993).

In sum, both the extrasyllabicity and the coda analyses assign the same structure to initial sT and TT. This would *ceteris paribus* predict simultaneous acquisition of initial sT and TT in languages that have both.

## 2.2 Goal of the experiment

The goal of this experiment is to test whether Greek children acquire word initial s+obstruent clusters (sT) before any other word initial obstruent-obstruent clusters (TT). In order to test this, I examined children's production of these clusters.

According to the experimental hypothesis ( $H_1$ ) we expect that children will perform better at sT clusters than at TT clusters. The null hypothesis ( $H_0$ ) is that there will be no difference in performance.

- |     |       |               |                       |
|-----|-------|---------------|-----------------------|
| 13. | $H_1$ | $\#sT > \#TT$ | > better performance  |
|     | $H_0$ | $\#sT = \#TT$ | = similar performance |

## 2.3 Methods and materials

The experiment consisted of two conditions; the first condition involved words with TT clusters in word initial position and the second condition involved words with sT clusters in word initial position. The TT condition has already been described in chapter 3, section 2.3. The same subjects, methodology and procedure were used in the second condition of the experiment, containing sT clusters. A non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children.

The clusters tested for the TT condition, repeated here for convenience, are the following:

14. *ft, xt, vð, γð, vy*

The stimuli used are listed in 15 below.

15. *ft'ipo* , *xt'ika*, *vð'ito*, *γð'oki*, *vy'api*.

The clusters tested in the sT condition contained *s* as their first member, and a stop or fricative as their second member.

16. *sp*, *st*, *sk*, *sf*, *sx*.

Some (real) Greek words containing sT clusters in word initial position are listed in 17 below.

17. *sp'ao* 'break' 1<sup>ST</sup> SG

*stamat'o* 'stop' 1<sup>ST</sup> SG

*sk'ilos* 'dog'

*sfir'izo* 'whistle' 1<sup>ST</sup> SG

*sx'ima* 'shape'

The design of the sT non-words followed the same principles as the ones followed in the previous experiments (chapter 3, section 3.3.3), forming feminine or neuter nouns. The stimuli were disyllabic, with a voiceless stop as an onset for the non-target syllable: *p*, *t* or *k*. The target clusters preceded the stressed vowel. The words were the following.

18. *sp'oki*, *st'ipo*, *sk'api*, *sf'ito*, *sx'ika*

Special care was taken, in the design of non-words, to include the same number of different segments in each of the two conditions. Specifically, each of the two conditions involved six different cluster-forming segments. The six segments of the TT condition were *f*, *x*, *v*, *t*, *ð*, *γ*. The six segments of the sT condition were *s*, *p*, *t*, *k*, *f*, *x*. This matching in the number of cluster-forming segments ensures that the probability of mistake because of segment variability is similar in the two conditions.

Moreover, the remaining segments and stress were identical in the two conditions: -'oki, -'ipo, -'api, -'ito, -'ika. Thus the two conditions were of comparable complexity.

## 2.4 Results

### 2.4.1 General results

The categories used for coding in the sT condition were the same as the ones used in the previous experiments. Table 1 shows the categories with an example for each, followed by some more examples.

Table 1. Categories used in coding with examples of corresponding responses

Code	Stimulus	Response
Correct	<i>st'ipo</i>	<i>st'ipo</i>
Drops 1 <sup>st</sup>	<i>sf'ito</i>	<i>f'ito</i>
Drops 2 <sup>nd</sup>	<i>st'ipo</i>	<i>s'ipo</i>
Other single	<i>sk'api</i>	<i>f'api</i>
Change one	<i>st'ipo</i>	<i>xt'ipo</i>
Other	<i>sx'ika</i>	<i>ks'ika</i>

#### 19. Correct

*st'ipo* → *st'ipo* (Nikos 4;03,17)

*sf'ito* → *sf'ito* (Katerina 3;11,25)

*sp'oki* → *sp'oki* (Manolio 3;06,17)

#### 20. Drops 1<sup>st</sup>

*sf'ito* → *f'ito* (Mariana 3;07,17)

*sk'api* → *k'api* (Giota 3;04,15)

*sx'ika* → *x'ika* (Aglaia 3;03)

#### 21. Drops 2<sup>nd</sup>

*st'ipo* → *s'ipo* (Manouela 2;11,19)

*st'ipo* → *s'ipo* (Despina 3;06,29)

*sx'ika* → *s'ika* (Pantelis 3;01,29)

## 22. Other single

*sk'api* → *f'api* (Vagelio 2;10,07)

*sf'ito* → *x'ito* (Giota 3;04,15)

*sx'ika* → *t'ika* (Emanouil 2;10,20)

## 23. Change one

*st'ipo* → *xt'ipo* (Sofia 3;01)

*sx'ika* → *st'ika* (Manolio 3;06,17)

*sx'ika* → *sk'ika* (Argiroula 3;04,01)

## 24. Other (different cluster, epenthesis or metathesis)

*sx'ika* → *ks'ika* (Dimitra 3;00,03)

*sf'ito* → *sx'ito* (Andreas 4;03,16)

The results for word initial sT are given in figure 1. The complete results are given in the appendix.

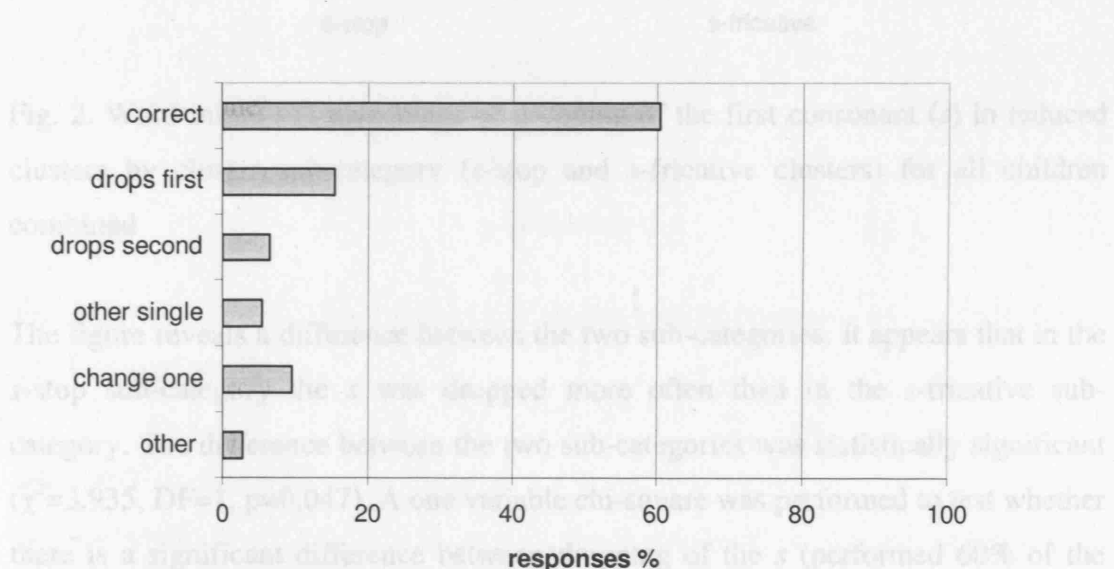


Fig. 1. Word initial sT clusters (n=293), percentage of responses by category for all children combined

Target responses represented around 60 percent of total responses. The most common mistake was dropping of the first consonant (the *s*), while the second consonant was dropped less often. There was a significant difference between dropping of the first and the second consonant ( $\chi^2=10.563$ ,  $DF=1$ ,  $p=0.001$ ).

The directionality of cluster reduction was also examined separately for the *s*+stop (*sp*, *st*, *sk*) and *s*+fricative (*sf*, *sx*) cluster sub-categories. Figure 2 shows the percentage of deletion of the first consonant (*s*) for the two sub-categories (for results table see appendix).

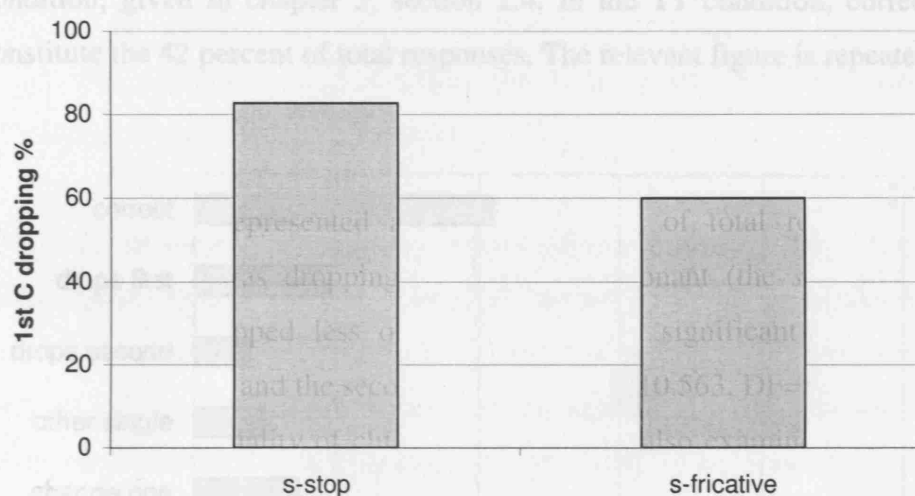


Fig. 2. Word initial *s*T: percentage of dropping of the first consonant (*s*) in reduced clusters by cluster sub-category (*s*-stop and *s*-fricative clusters) for all children combined

The figure reveals a difference between the two sub-categories. It appears that in the *s*-stop sub-category the *s* was dropped more often than in the *s*-fricative sub-category. The difference between the two sub-categories was statistically significant ( $\chi^2=3.935$ ,  $DF=1$ ,  $p=0.047$ ). A one variable chi-square was performed to test whether there is a significant difference between dropping of the *s* (performed 60% of the time) and dropping of the fricative (performed 40% of the time) in the *s*-fricative sub-category. The  $\chi^2$  value of 1.400 had an associated probability value of  $p=0.237$ ,  $DF=1$ , showing that the difference between the dropping of the *s* and the fricative is not statistically significant in this sub-category. In the *s*-stop sub-category, a  $\chi^2$  value of 12.448,  $DF=1$  was found to have an associated probability value of  $p<0.001$ ,

indicating that the two consonants were not dropped equally often in that sub-category. As we can see in figure 2, the *s* was dropped more often than the stop.

Such results are consistent with the tendency reported in language acquisition studies, of dropping the most sonorous consonant and retaining the less sonorous one (see e.g. Gnanadesikan (2004), Ohala (1999), Pater & Barlow (2003), see chapter 1, section 3.3). According to our results, in fricative-stop (*s*-stop) clusters, the fricative (*s*) was dropped more often, while in fricative-fricative (*s*-fricative) clusters, neither of the two fricatives was dropped more often.

Compare the results for the *sT* condition with the results for the *TT* condition, given in chapter 3, section 2.4. In the *TT* condition, correct responses constitute the 42 percent of total responses. The relevant figure is repeated below.

Fig. 3. Percentage of correct responses for word initial *TT* versus word initial *sT* clusters for all children combined

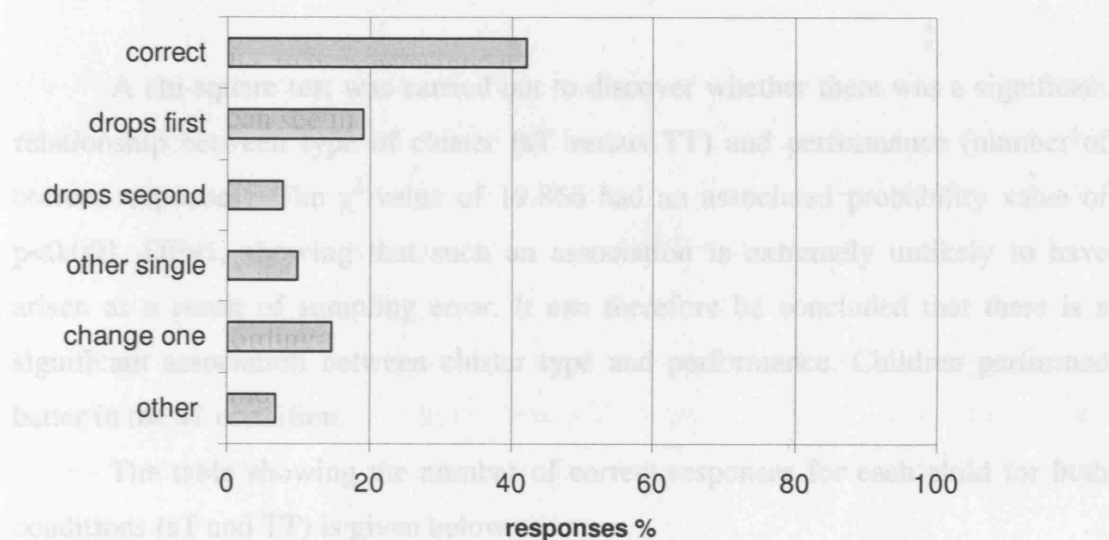


Fig. 3. Word initial *TT* clusters (n=295), percentage of responses by category for all children combined

## 2.4.2 #*sT* versus #*TT*

In a comparison of the percentages of correct responses in the two conditions, a difference appears. In the *sT* condition, children gave correct responses around 60 percent of the time, while in the *TT* condition correct responses were 42 percent of the total (figure 4).

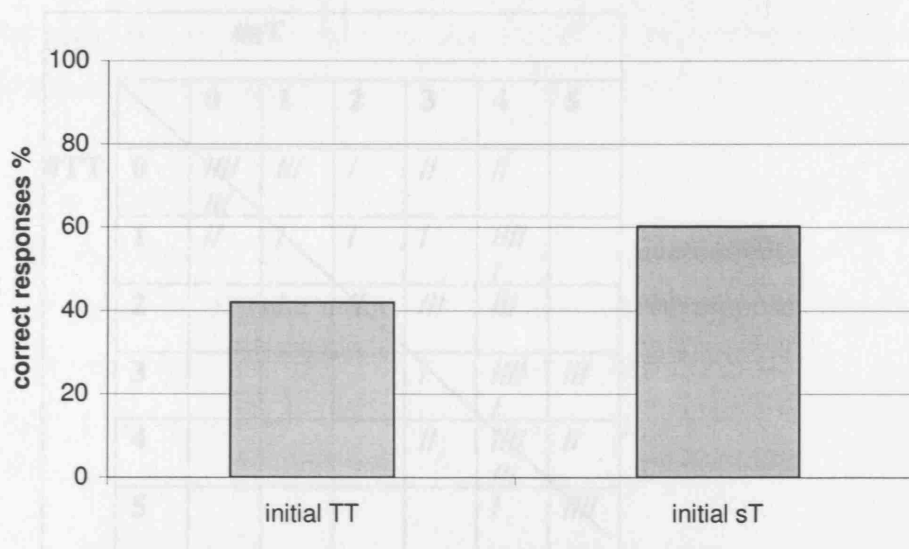


Fig. 4. Percentage of correct responses for word initial TT versus word initial sT clusters for all children combined

A chi-square test was carried out to discover whether there was a significant relationship between type of cluster (sT versus TT) and performance (number of correct responses). The  $\chi^2$  value of 19.866 had an associated probability value of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between cluster type and performance. Children performed better in the sT condition.

The table showing the number of correct responses for each child for both conditions (sT and TT) is given below.

We expect that the top right sector will contain a greater number of children; more children will perform better at sT than at TT.

A visual examination of the table shows that this is true. Most children performed better at sT than at TT. The top right sector is populated much more than the bottom left one. The difference is striking, as there is a large number of children that performed well at sT and badly at TT, while few children performed better at TT than at sT. Some examples of individual children's performance are given below. Agaton (25a) and Maro (20b) performed very well at sT and very badly at TT. Zoë's

<sup>1</sup> In the case of children that performed better at TT, the difference between TT and sT is consistently small: specifically, there were only cases of one response difference (1-0, 2-1, 4-3, 5-4) (see table 2).

		#sT					
#TT		0	1	2	3	4	5
	0	///	///	/	//	//	
	1	///	///	/	/	///	
	2	///	/	/	///	///	
	3	///			/	///	///
	4	///			///	///	///
	5	///				/	///

Table 2: Number of correct responses for #sT and #TT for each child

The vertical dimension represents the number of correct responses in the TT condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the sT condition (again from zero to five). Each tally mark in a table cell represents a child (total 59 children). For example, fifteen children (in the first row) gave no correct responses in the TT condition. Children are divided into two groups, represented by the two sectors divided by the diagonal line: the top right sector contains children that performed better at sT, while the bottom left sector consists of children that performed better at TT. Children that fall on the diagonal performed the same in both positions.

We expect that the top right sector will contain a greater number of children; more children will perform better at sT than at TT.

A visual examination of the table shows that this is true. Most children performed better at sT than at TT. The top right sector is populated much more than the bottom left one. The difference is striking, as there is a large number of children that performed well at sT and badly at TT, while few children performed better at TT than at sT<sup>4</sup>. Some examples of individual children's performance are given below. Agelos (25a) and Maro (25b) performed very well at sT and very badly at TT. Zoi's

<sup>4</sup> In the cases of children that performed better at TT, the difference between TT and sT is consistently small: specifically, there were only cases of one response difference (1-0, 2-1, 4-3, 5-4) (see table 2).



(25c) performance at TT was better than that of the two previous children, and at sT her performance was adult-like.

25. a. Agelos (3;04,12)

#sT: 4 out of 5 target

*sk'api* → *sk'api*

*sp'oki* → *sp'oki*

*st'ipo* → *st'ipo*

*sf'ito* → *sf'ito*

*sx'ika* → *sk'ika*

#TT: 0 out of 5 target

*xt'ika* → *ft'ika*

*ft'ipo* → *st'ipo*

*vð'ito* → *v'ito*

*γð'oki* → *xr'oki*

*vγ'api* → *γ'api*

b. Maro (3;09,23)

#sT: 4 out of 5 target

*sp'oki* → *sp'oki*

*st'ipo* → *st'ipo*

*sk'api* → *sk'api*

*sx'ika* → *sx'ika*

*sf'ito* → *f'isto*

#TT: 1 out of 5 target

*ft'ipo* → *ft'ipo*

*xt'ika* → *t'ika*

*vð'ito* → *ð'ito*

*γð'oki* → *ði'oki*

*vγ'api* → *vg'api*

c. Zoi (4;02,17)

#sT: 5 out of 5 target

*sp'oki* → *sp'oki*

*st'ipo* → *st'ipo*

*sk'api* → *sk'api*

*sx'ika* → *sx'ika*

*sf'ito* → *sf'ito*

#TT: 3 out of 5 target

*vγ'api* → *vγ'api*

*xt'ika* → *xt'ika*

*γð'oki* → *γð'oki*

*vð'ito* → *ð'ito*

*ft'ipo* → *xt'ipo*

In order to test the difference between the two sectors, a one-variable chi-square test was performed. The  $\chi^2$  value of 16.9 DF=1 had an associated probability value of  $p=0.001$ . Based on this statistically significant result we can conclude that the two sectors are not equally populated. More children performed better at sT than at TT.

Moreover, the coding of the responses was performed for a second time, following the alternative criteria discussed in chapter 3, section 2.4.3. Specifically, the original coding protocol dictated that we code as ‘correct’ only responses with a consonant cluster that is identical to the target one. According to the alternative criteria, I code as correct any responses that involve a cluster belonging to the same category as the target one, even if it is not the target one. This includes any obstruent-obstruent cluster in the TT condition (for examples of such responses see chapter 3, section 2.4.3), and any *s*-obstruent cluster in the *s*T condition. Some examples of such responses in the *s*T condition are given below.

26. *sx'ika* → *st'ika* (Manolio 3;06,17)

*sx'ika* → *sk'ika* (Antonis 3;06,04)

*sp'oki* → *sv'oki* (Mario 3;03,01)

In addition to this change, a second change to the criteria was applied, for *s*T clusters in particular. Some responses involve a substitution (of one consonant for another) that the child consistently makes in single consonant production. For example, some children consistently substitute *θ* for *s*. When these children used *θ* in clusters with target *s*, the original coding protocol demanded that the response be coded as correct (see chapter 3, section 2.3.5).

27. *sf'ito* → *θf'ito* (Fenia 3;01)

*sf'ipo* → *θf'ipo* (Kali 3;00)

*st'ipo* → *θt'ipo* (Kali 3;00)

However, if we assume that *s*T clusters owe something to the special nature of *s*, we may wish not to consider these pseudo-*s*T clusters as target, since they do not involve the segment *s*. Consequently, the coding of the responses was repeated, this time demanding that pseudo-*s*T clusters be coded as non-correct.

The coding was subsequently repeated, according to the alternative criteria outlined above. There was a 4.8% increase of responses coded as correct in the *s*T condition, and a 9.5% in the TT condition (for raw numbers see appendix). Figure 5 shows the percentages of correct responses in the two conditions.

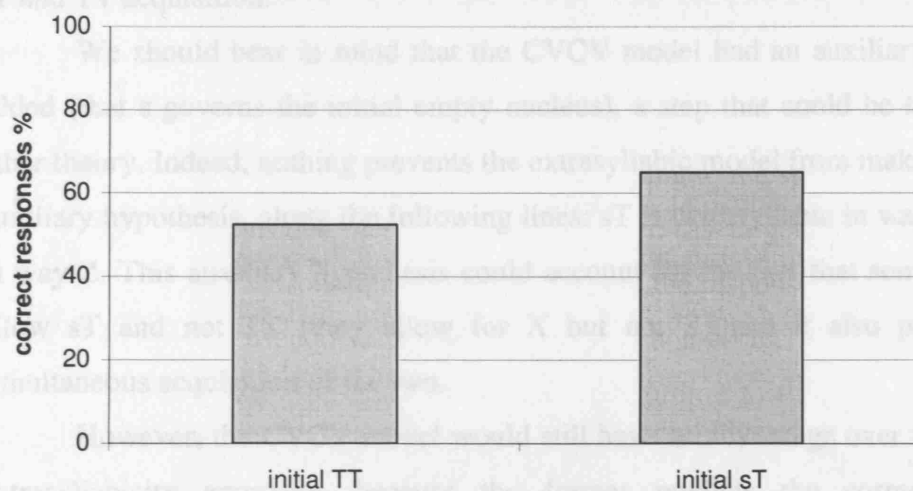


Fig. 5. Percentage of correct responses for word initial TT versus word initial sT clusters for all children combined, according to alternative criteria

The relationship between the results in the two conditions appears to be the same: the percentage of correct responses in the sT condition is higher than in the TT condition.

As before, a chi-square test was carried out to discover whether there was a significant relationship between type of cluster (sT versus TT) and performance (number of correct responses). The  $\chi^2$  value of 9.706 had an associated probability value of 0.002, DF=1, showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between cluster type and performance. The alternative coding criteria did not alter the result: with the original, as well as with the alternative criteria, children's performance in the sT condition was found to be better than in the TT condition.

## 2.5 Analysis

The statistical analysis of the results gives support to the experimental hypothesis, namely that initial sT is acquired before initial TT. Children's performance was significantly better at sT, showing that acquisition of sT precedes that of TT. The prediction of the CVCV parametric model is thus borne out. In contrast, it turns out

that extrasyllabicity and coda analyses make the wrong prediction of simultaneous sT and TT acquisition.

We should bear in mind that the CVCV model had an auxiliary hypothesis added (that *s* governs the initial empty nucleus), a step that could be taken by any other theory. Indeed, nothing prevents the extrasyllabic model from making a similar auxiliary hypothesis, along the following lines: sT is extrasyllabic in way X, and TT in way Z. This auxiliary hypothesis could account for the fact that some languages allow sT and not TT (they allow for X but not Z) and it also predicts non-simultaneous acquisition of the two.

However, the CVCV model would still have an advantage over the amended extrasyllabicity approach, because the former predicts the correct order of acquisition. Specifically, CVCV predicts that sT is acquired before TT: once the auxiliary hypothesis is made, the prediction follows from the theory as a theoretical necessity. In contrast, extrasyllabicity would further have to stipulate that X is acquired before Z. If TT was found to be acquired before sT, extrasyllabicity could simply stipulate that it is Z that is acquired before X, and thus be made consistent with the opposite reality.

Regarding the question of whether the addition of the auxiliary hypothesis constitutes any progress, note that CVCV without the auxiliary hypothesis would not have made any prediction on the acquisition of sT and TT (in either direction): it would have nothing to say about this domain. The only type of acceptable auxiliary hypothesis is one that does not diminish the degree of falsifiability or testability of the system in question, but, on the contrary, increases it. And this is exactly what our auxiliary hypothesis does. Moreover, the auxiliary hypothesis is more than a mere taxonomical observation. We could classify the clusters as different, but we would not know the direction of the difference in acquisition.

Most importantly, CVCV with the addition of the auxiliary hypothesis can account for an apparent paradox: in languages that have both, sT and TT show identical behaviour in some adult language phenomena, but behave differently in acquisition. Specifically, there is evidence from languages that have both sT and TT that the two are syllabically the same (Seigneur-Froli 2006; Steriade 1982). A well-known example is attic Greek reduplication: past forms of roots beginning with sT and TT follow the same pattern, in contrast to TR beginning verbs. The imperfective past forms of roots commencing with a single consonant (including *s*) are formed by

reduplication; an initial syllable consisting of the first consonant followed by *e* is added (28a). In the case of roots commencing with TR clusters, reduplication also takes place (the initial syllable consists of the obstruent plus *e*) (28b). In contrast, in the case of roots commencing with TT no reduplication takes place: the vowel *e* is added word initially (28c). As for the past forms of roots starting with sT, these are formed in the same way as TT initial roots (28d).

28. a. CV

Present	Past	
<i>paide<sup>1</sup>u-oo</i>	<i>pep<sup>1</sup>aideuka</i>	‘bring up’
<i>l<sup>1</sup>uoo</i>	<i>l<sup>1</sup>eluka</i>	‘loosen’
<i>sale<sup>1</sup>uoo</i>	<i>ses<sup>1</sup>aleumai</i>	‘cause to rock’

b. TR

<i>kr<sup>1</sup>inoo</i>	<i>k<sup>1</sup>ekrika</i>	‘pick out’
<i>kl<sup>1</sup>inoo</i>	<i>k<sup>1</sup>eklika</i>	‘make to bend’
<i>pl<sup>1</sup>eo</i>	<i>p<sup>1</sup>epleuka</i>	‘sail’

c. TT

<i>pt<sup>1</sup>aioo</i>	<i><sup>1</sup>eptaika</i>	‘make to stumble’
<i>kt<sup>1</sup>einoo</i>	<i><sup>1</sup>ektaamai</i>	‘kill’
<i>p<sup>h</sup>t<sup>h</sup>anoo</i>	<i><sup>1</sup>ep<sup>h</sup>t<sup>h</sup>aka</i>	‘come first’

d. sT

<i>sp<sup>1</sup>ao</i>	<i><sup>1</sup>espaka</i>	‘draw’ (a sword)
<i>st<sup>1</sup>ello</i>	<i><sup>1</sup>estalka</i>	‘arrange’
<i>ski<sup>1</sup>azoo</i>	<i><sup>1</sup>eskiasmai</i>	‘shade’

Such behaviour has led phonologists to conclude that sT and TT in (ancient) Greek have the same structure (Seigneur-Froli 2006; Steriade 1982). On the other hand, our experimental results demonstrate that sT and TT are different in some way crucial to

first language acquisition. The question arises, if sT and TT have the same syllabic structure, why are they not acquired together?

This discrepancy between adult language and first language acquisition is predicted by the CVCV model (with the auxiliary hypothesis). As discussed earlier, sT is acquired before TT because it requires a subset of marked parameter settings. Following the assumption that the *s* can govern the initial empty nucleus, sT is allowed at a stage when the child's grammar has a plus setting for government, but still has an initial ON pair. At this stage, initial TT is disallowed (29).

#### 29. Stage n-1 of acquisition:

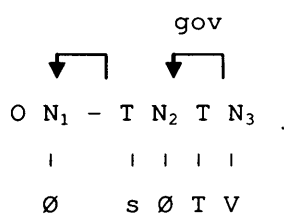
Grammar: Nuclei+govern

Initial clusters: sT yes

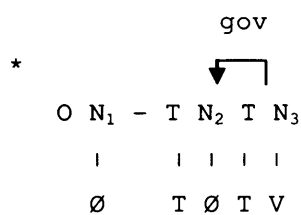
Initial ON: Yes

TT no

##### a. sT well formed



##### b. TT ill-formed



At a subsequent stage, when the Initial ON is dropped (the parameter gets fixed to the marked setting) TT clusters appear. At this stage, initial sT ends up having the same structure as initial TT. This is the end-stage of the acquisition process with respect to these two parameters (30).

#### 30. Stage n of acquisition

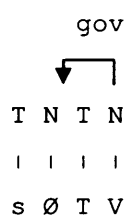
Grammar: Nuclei+gov

Initial clusters: sT yes

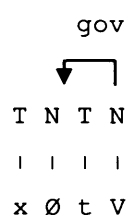
Initial ON: No

TT yes

##### a. sT well formed



##### b. TT well formed



At this stage, which corresponds to the adult language, initial sT and TT have the same structure, since the Initial ON pair of stage n-1 is no longer there. This explains the identical behaviour of sT and TT in adult language.

This discrepancy between child and adult language is predicted by CVCV theory. The addition of the auxiliary hypothesis was what opened up this possibility. CVCV would not have been able to account for this discrepancy without the addition of the auxiliary hypothesis.

### 3 #sT and #TT versus #TR

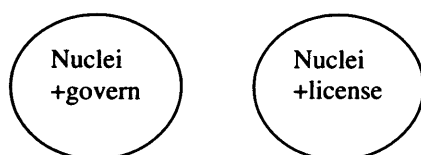
#### 3.1 The prediction

##### 3.1.1 CVCV

The relationship between word initial sT and word initial TR clusters has received considerable attention from acquisition researchers. Here, the unusual behaviour of sT appears once again: sT can be acquired after, but also before TR. Several studies have shown that children start producing initial sT clusters after TR clusters (e.g. Chin (1996), Smith (1973)). However, other studies (e.g. Barlow (1997), Gierut (1999)) found that some children produce initial sT clusters first.

How does the CVCV model account for such a peculiar behaviour? Initial sT can be acquired before or after TR because each cluster type requires one marked setting, of two parameters that are independent from each other. sT requires the marked setting of the Nuclei+/-govern parameter, while TR requires the marked setting of the Nuclei+/-license parameter. The requirements for the two clusters form independent sets that do not create an intersection.

#### 3.1. Two independent sets



Left oval: requirements for #sT

Right oval: requirements for #TR

Government and Licensing are independent parameters<sup>5</sup> (one is not a prerequisite for the other), and as such, either of the two can move to the marked setting first. Consequently, some of the children will acquire sT first, others TR first, and in some cases the two cluster types may appear simultaneously. This analysis can thus account for the puzzle of sT versus TR acquisition.

With regard to initial TT versus initial TR acquisition, to my knowledge, no such study has been conducted. The prediction of the CVCV model is that TR is acquired before TT. The reasoning is that the marked settings required for TR form a subset of the marked settings required for TT. Specifically, TR requires one marked setting, of the Nuclei+/-license parameter, while TT requires two marked settings, of the Nuclei+/-govern and of the Initial ON parameter.

The requirements for the two cluster types do not form a subset relation in the strict sense: #TT requires a higher number of marked settings, but of parameters different from those required for #TR. This absence of a subset relation in the requirements of the two cluster types tallies with the absence of an implicational universal regarding the two cluster types in language typology. However, careful examination reveals that, for the purposes of language acquisition, the requirements enter, in fact, into a type of subset relation. The key to this lies in the nature of the relevant parameters. One of the two marked settings required for #TT (Nuclei+govern) is of the same nature as the marked setting required for #TR (Nuclei+license). These two parameters control government and licensing respectively, which are the primary lateral forces of the theory. They are primary in that they are the basic building blocks of syllabic structure (in conjunction with the ECP), as well as the sources of segmental effects. Moreover, they both originate from a nucleus and target the preceding empty nucleus, either directly – in the case of government – or via the creation of a domain of infrasegmental government enclosing the empty nucleus – in the case of licensing. As such, it is expected that children acquiring a language that has marked settings for both parameters will switch to the marked settings at roughly the same time and in either order. Indeed, this is the basis of the analysis proposed for the variation found in #sT-#TR acquisition. In this sense, the Nuclei+govern requirement of #TT is equivalent to the Nuclei+license requirement of #TR.

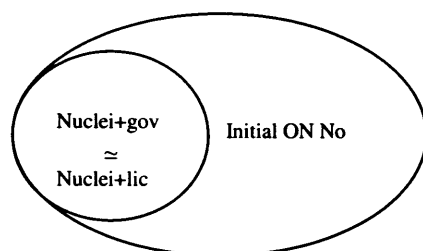
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<sup>5</sup> Cf. section 6.



In addition to this, #TT also requires an extra marked setting, of the Initial ON parameter, which is a parameter of a different type (presence versus absence of an object) and it has as a prerequisite that the Nuclei+/- govern parameter be at the marked setting (see chapter 2, section 6.3). This examination of the requirements for #TR and #TT allows us to detect a subset-superset relation: the requirement for #TR, Nuclei+license, is equivalent to one of the requirements for #TT, Nuclei+govern. #TT has an additional requirement, namely Initial ON No. This is schematically given below.

### 32. A subset relation



Small oval: conditions for word initial TR

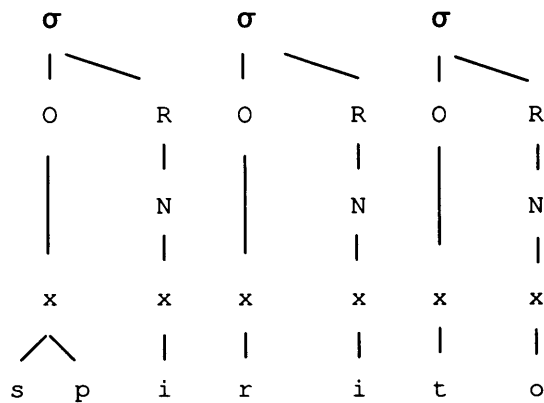
Large oval: conditions for word initial TT

Such a subset relation, where the requirements for #TR are a proper subset of the requirements for #TT, predicts earlier acquisition of #TR.

### 3.1.2 Other approaches

The variation in the order of #sT-#TR acquisition has long puzzled researchers and there have been a number of proposals developed in order to tackle this problem. For example, it has been suggested that the explanation for these data lies in the possibility that some children acquire branching onset structures (TR) before extrasyllabicity, while others acquire extrasyllabic structures first (Fikkert 1994). This assumes that extrasyllabicity and branching onsets (TR) are different, but equally marked structures, and the order of acquisition is therefore subject to variation. A different suggestion holds that extrasyllabic clusters (and more generally consonantal sequences) may be structured like affricates in acquisition (Barlow (1997), Lleó & Prinz (1997)). The relevant structure is shown below.

### 33. sT as an affricate: Italian *sp<sup>l</sup>irito*



As seen in 33, sT clusters are represented as complex segments with a single timing slot. According to this approach, if a child does not structure sT like an affricate, s/he will acquire it after TR (as extrasyllabic, and therefore more marked). If, on the other hand, in a developing grammar, sT is structured like an affricate, it will be acquired before TR (on the assumption that complex segments are less marked than complex onsets). This optionality of structure, it is argued, can account for the variation in #sT-#TR acquisition. However, this approach does not seem to be particularly insightful, as it does not define what circumstances regulate whether a consonantal sequence will be structured as an affricate or as a cluster<sup>6</sup>.

As for TT, an analysis that assumes extrasyllabicity of initial clusters of non-rising sonority will predict the same variation in TT versus TR acquisition as in sT versus TR acquisition. If TT is extrasyllabic like sT, and sT is acquired before or after TR, then TT is expected to be acquired before or after TR. Both analyses of sT versus TT acquisition outlined above (that extrasyllabicity can be acquired before or after TR, or that extrasyllabic clusters can be structured as complex segments in acquisition) would make the same prediction in this case. This is in sharp contrast with the CVCV model, which predicts earlier acquisition of #TR.

## 3.2 Goal of the experiment

The goal of the experiment is twofold. Firstly, to replicate the findings of acquisition studies with regard to the acquisition of sT versus TR in word initial position.

<sup>6</sup> See also Scobbie (1997) for a conceptually motivated criticism of the contour segment analysis.

Specifically, we expect to find variation in the order of acquisition. We expect that some children will perform better at sT, while others will be better at TR and as a result no overall difference between sT and TR will arise.

Secondly, and most importantly, #TT acquisition is compared to #TR acquisition. Word initial TR is expected to be acquired before word initial TT. The experimental hypothesis is that children will perform better at #TR. The null hypothesis is that there will be no difference in their acquisition.

### 3.3 Methods and materials

This investigation consists of two parts: The first part involves a #sT-#TR comparison, and the second one a #TT-#TR one.

The data used in this investigation is taken from experiments described earlier in this thesis. Three sets of data are used: children's production of #sT clusters (section 2), the same children's production of #TR clusters (chapter 3, section 3) and #TT clusters (chapter 3, section 2). Information on the subjects, materials, methodology and procedure can be found in these sections. In all cases, a non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children.

The clusters tested for each of the three conditions are repeated here for convenience.

- 34. a. #sT clusters: *sp, st, sk, sf, sx*
- b. #TR clusters: *tr, kl, fl, xr, vr*
- c. #TT clusters: *ft, xt, vð, γð, vy*

The non-words are given in 35 below. Their design is explained at the corresponding sections mentioned above.

- 35. a. #sT: *sp'oki, st'ipo, sk'api, sf'ito, sx'ika*
- b. #TR: *tr'ika, kl'ito, fl'api, xr'oki, vr'ipo*
- c. #TT: *ft'ipo, xt'ika, vð'ito, γð'oki, vy'api*

### 3.4 Results

The detailed results for each of the three cluster types can be found in section 2.4 for #sT, chapter 3, section 3.4 for #TR and chapter 3, section 2.4 for #TT. Figure 6 below contains the percentage of correct responses for each of the clusters.

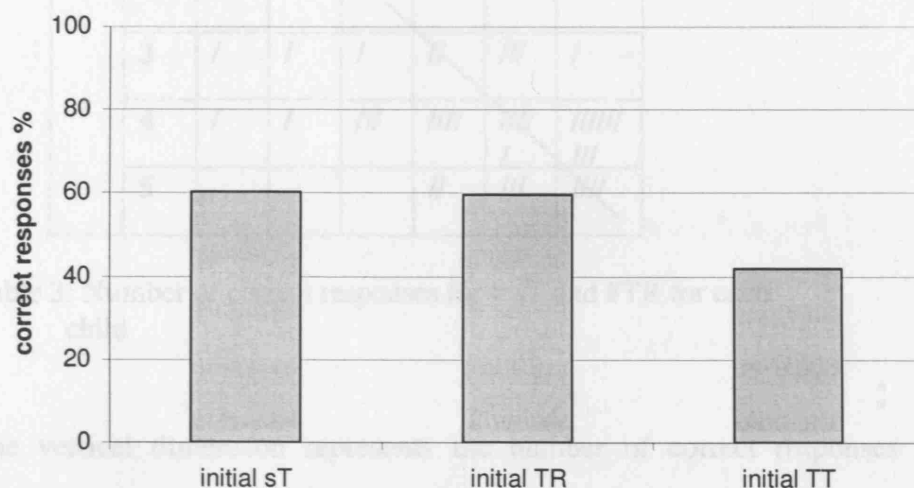


Fig. 6. Percentage of correct responses for word initial sT, TR and TT clusters for all children combined

The results for #sT and #TR are very similar. A chi-square test was carried out to discover whether there was a significant relationship between type of cluster (#sT versus #TR) and performance (number of correct responses). The  $\chi^2$  value of 0.034 had an associated probability value of  $p=0.859$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. The test found no significant difference between #sT and #TR with regard to the number of correct responses.

In addition, the table showing the number of correct responses for each child for the two conditions (#sT and #TR) was drawn.

		#TR					
#sT		0	1	2	3	4	5
	0	///	//	//		/	
	1	//			//	/	
	2	/		//		/	
	3	/	/	/	//	///	/
	4	/	/	///	////	///	////
	5				//	///	///

Table 3: Number of correct responses for # sT and #TR for each child

The vertical dimension represents the number of correct responses in the #sT condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the #TR condition (again from zero to five – for more details on this data arrangement, see section 2.4.3). The top right and the bottom left sector (divided by the diagonal line), corresponding to children that performed better at #TR and #sT respectively, are equally populated. A one-variable chi-square test that was carried out to test the difference between the two sectors had a  $\chi^2$  value of 0.095, with an associated probability value of  $p=0.758$ ,  $DF=1$ . The test found no statistically significant difference between the two sectors.

Moreover, the tally marks representing the children are scattered all over the table, showing that there is wide variation in performance. This includes children that performed almost adult-like in #sT but badly at #TR, and vice-versa, as well as children that were equally advanced in the two cluster types. Some examples of children, characteristic of the diversity, are given below. Kostantinos (36a) performed very badly at #sT and very well at #TR, while Fanouris (36b) showed the opposite pattern. Aglaia (36c) had roughly the same performance for the two cluster types, being only slightly better at #sT (3 correct responses out of 5 as opposed to 2 out of 5 for #TR).

36. a. Kostantinos (2;11,17)

#sT: 1 out of 5 target

*sk'api* → *θk'api*

*sp'oki* → *p'oki*

*st'ipo* → *θ'ipo*

*sf'ito* → *f'ito*

*sx'ika* → *ç'ika*

#TR: 4 out of 5 target

*kl'ito* → *kl'ito*

*vr'ipo* → *vr'ipo*

*xr'oki* → *xr'oki*

*tr'ika* → *tr'ika*

*fl'api* → *xl'api*

b. Fanouris (3;04,15)

#sT: 4 out of 5 target

*sp'oki* → *sp'oxi*

*st'ipo* → *st'ipo*

*sk'api* → *sk'api*

*sf'ito* → *sf'ito*

*sx'ika* → *x'ika*

#TR: 1 out of 5 target

*fl'api* → *fl'a*

*kl'ito* → *pl'ito*

*vr'ipo* → *l'ipo*

*xr'oki* → *l'oki*

*tr'ika* → *t'ika*

c. Aglaia (3;03)

#sT: 3 out of 5 target

*sk'api* → *sk'api*

*sp'oki* → *sp'oki*

*st'ipo* → *st'ipo*

*sf'ito* → *f'ito*

*sx'ika* → *x'ika*

#TR: 2 out of 5 target

*kl'ito* → *kl'ito*

*fl'api* → *fl'api*

*vr'ipo* → *pt'ipo*

*xr'oki* → *k'oki*

*tr'ika* → *t'ika*

In a #TT versus #TR comparison, figure 6 shows a considerable difference in the percentage of correct responses. A two-variable chi-square test was carried out to discover whether there was a significant relationship between type of cluster (#TT versus #TR) and performance (number of correct responses). The  $\chi^2$  value of 18.337 had an associated probability value of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between cluster type and performance. In other words, children gave more correct responses in one of the two

conditions. By looking at figure 6, we can see that it is at the #TR condition that children performed significantly better.

As before, the table containing the number of correct responses for each child for both conditions (#TT versus #TR) was drawn.

		#TR					
#TT		0	1	2	3	4	5
	0	///	//	/	//	/	/
	1	////	/	////	/	//	//
	2	/		//	//	///	/
	3			/	/	///	////
	4		/		///	////	///
	5				/	/	///

Table 4: Number of correct responses for #TT and #TR for each child

The vertical dimension represents the number of correct responses in the #TT condition (from zero to five), while the horizontal dimension shows the number of correct responses in the #TR condition (again from zero to five). A visual examination of the table shows that the top right sector, corresponding to children that performed better at #TR, is much more populated than the bottom left sector, which includes children that performed better at #TT. Several children performed well at #TR and badly at TT, while the reverse pattern was uncommon<sup>7</sup>. In 37 I give some examples of individual children's performance. Kostantinos (37a) and Agelos (37b) performed very well at #TR and badly at #TT. Zoi (37c) performed better than the two previous children at #TT and adult-like at #TR.

<sup>7</sup> In the cases of children that performed better at TT, the difference between TT and TR is small: specifically, there were only cases of one response difference (3-2, 4-3, 5-4), two responses difference (2-0, 5-3) and one case of three responses difference (4-1) (see table 4).

37. a. Kostantinos (2;11,17)

#TR: 4 out of 5 target

*tr'ika* → *tr'ika*

*kl'ito* → *kl'ito*

*xr'oki* → *xr'oki*

*vr'ipo* → *vr'ipo*

*fl'api* → *xl'api*

#TT: 1 out of 5 target

*ft'ipo* → *ft'ipo*

*vð'ito* → *v'ito*

*γð'oki* → *ð'oki*

*vγ'api* → *γ'api*

*xt'ika* → *t'ixa*

b. Agelos (3;04,12)

#TR: 5 out of 5 target

*tr'ika* → *tr'ika*

*kl'ito* → *kl'ito*

*xr'oki* → *xr'oki*

*vr'ipo* → *vr'ipo*

*fl'api* → *fl'api*

#TT: 0 out of 5 target

*xt'ika* → *ft'ika*

*ft'ipo* → *st'ipo*

*vð'ito* → *v'ito*

*γð'oki* → *xr'oki*

*vγ'api* → *γ'api*

c. Zoi (4;02,17)

#TR: 5 out of 5 target

*tr'ika* → *tr'ika*

*kl'ito* → *kl'ito*

*xr'oki* → *xr'oki*

*vr'ipo* → *vr'ipo*

*fl'api* → *fl'api*

#TT: 3 out of 5 target

*vγ'api* → *vγ'api*

*xt'ika* → *xt'ika*

*γð'oki* → *γð'oki*

*vð'ito* → *ð'ito*

*ft'ipo* → *xt'ipo*

A one-variable chi-square test was carried out in order to test whether the difference between the two sectors is statistically significant. The  $\chi^2$  value of 14.400 had an associated probability value of  $p < 0.001$ ,  $DF = 1$ . There is a statistically significant difference between the two sectors.

Moreover, the comparison of children's performance in the three conditions was repeated, this time following the alternative criteria discussed in section 2.4.3. Specifically, while the original coding protocol so far dictated that we code as



'correct' only responses with a consonant cluster that is identical to the target one, according to the alternative criteria, all responses that involve a cluster belonging to the same category as the target one, are coded as correct (for more details and examples see section 2.4.2 for sT, chapter 3, section 2.4.3 for TT and chapter 3, section 3.4.2 for TR). Figure 7 below contains the percentage of correct responses for each of the three conditions under the alternative coding criteria.

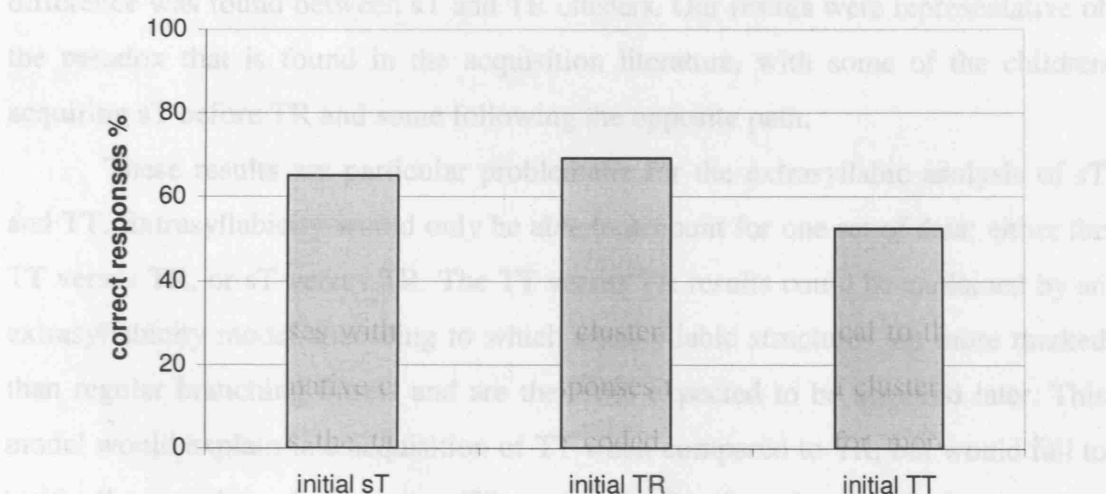


Fig. 7. Percentage of correct responses for word initial sT, TR and TT clusters for all children combined, according to alternative criteria

As before, a chi-square test was carried out to discover whether there was a significant relationship between type of cluster and performance (number of correct responses). In the case of sT versus TR, the  $\chi^2$  value of 1.048 had an associated probability value of  $p=0.306$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. In the case of TR versus TT comparison, the  $\chi^2$  value of 17.082 had an associated probability value of  $p<0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between cluster type and performance. The alternative coding criteria did not alter the result: with the original, as well as with the alternative criteria, no overall difference was found between children's performance in the sT condition and the TR condition, while under both coding criteria performance in the TR condition was found to be better than in the TT condition.

### 3.5 Analysis

The statistical analysis of the results gives support to the experimental hypothesis, with regard to #TT versus #TR acquisition, namely that TT is acquired after TR. Children performed significantly better at TR, showing that acquisition of TR precedes that of TT.

The results regarding #sT versus #TR were as expected. No overall difference was found between sT and TR clusters. Our results were representative of the paradox that is found in the acquisition literature, with some of the children acquiring sT before TR and some following the opposite path.

These results are particularly problematic for the extrasyllabic analysis of sT and TT. Extrasyllabicity would only be able to account for one set of data: either the TT versus TR, or sT versus TR. The TT versus TR results could be explained by an extrasyllabicity model according to which extrasyllabic structures are more marked than regular branching onsets and are therefore expected to be acquired later. This model would explain late acquisition of TT when compared to TR, but would fail to tackle the paradox of sT versus TR variation. On the other hand, the amended extrasyllabicity proposals discussed in section 3.1.2 – namely a) that extrasyllabicity can be acquired before or after branching onsets, and b) that in some children's grammar, extrasyllabic clusters are structured like affricates, and are therefore acquired before branching onsets – would cover the data they were designed to explain (sT-TR variation) but would fail to cover the TT versus TR data. Any such proposal would have to answer why the same variation is not found in TT versus TR acquisition. Either way, the results are problematic for the extrasyllabic approach<sup>8</sup>.

The results are consistent with the CVCV parametric model, which predicts earlier acquisition of TR compared to TT, and can explain the variation in sT-TR acquisition. The reason in both cases lies in the relationship between the requirements for each of the two clusters. When the requirements are equal but independent, as in sT versus TR, then variation in the order of acquisition is

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<sup>8</sup> In order to account for the data, it would be possible to add an auxiliary hypothesis claiming two different kinds of extrasyllabicity, one for sT and one for TT. However, this would not be enough: we would still have to stipulate the order of acquisition of these different structures (see discussion in section 2.5).

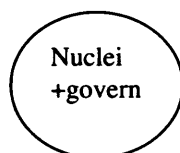
expected. When the requirements form a subset-superset relationship, as in the TR versus TT case, then the cluster with the subset requirements (in this case TR) is expected to be acquired first.

## 4 #sT versus -sT

### 4.1 The prediction

According to the CVCV model developed here, the requirements for word initial sT are the same as those for word medial sT clusters. Specifically, in both cases a single marked setting is required: Nuclei+govern.

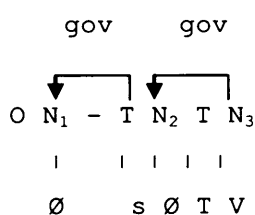
#### 38. Set identity



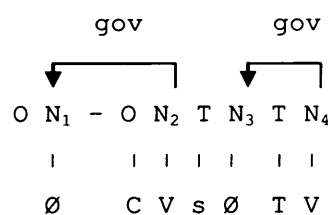
oval : requirements for -sT and #sT

The relevant structures for word initial and word medial sT are given in 39a and 39b respectively.

#### 39. a. Word initial sT



#### b. Word medial sT



Identity of the requirements for the two structures predicts simultaneous acquisition of the cluster in the two positions.

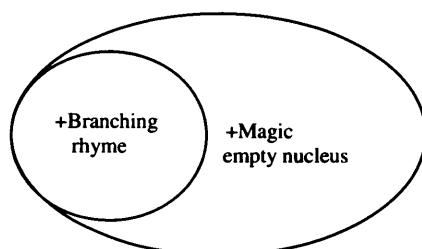
In this section I refrain from comparing the predictions of CVCV with a prediction made by the extrasyllabic approach. Extrasyllabicity has undergone numerous alternative modifications (see section 3.1.2), so that any result in an initial versus medial sT comparison will be consistent with at least one of them. However, I

believe that I have provided sufficient evidence against extrasyllabicity in the previous sections of this chapter.

Instead, the prediction will be compared with that made by the Government Phonology analysis briefly mentioned in section 2.1.2, as that has been applied to first language acquisition by Pan (2005) (see also Pan & Snyder (2004)). The analysis holds that *s* in word initial sT clusters is a coda consonant preceded by an empty nucleus.

Pan, as mentioned in chapter 1, section 4.3, uses a Branching rhyme parameter, a marked setting of which is the requirement for word medial codas. Moreover, she proposes a Magic empty nucleus parameter, to capture Kaye's (1992) analysis of the *s* in sT as a coda preceded by an empty nucleus, and suggests that the requirement for word initial sT clusters is a marked value for both these parameters (i.e. Branching rhyme and Magic empty nucleus parameters). The requirements for word medial sT are thus a proper subset of those for word initial sT.

#### 40. #sT and –sT according to Pan (2005): A subset relation



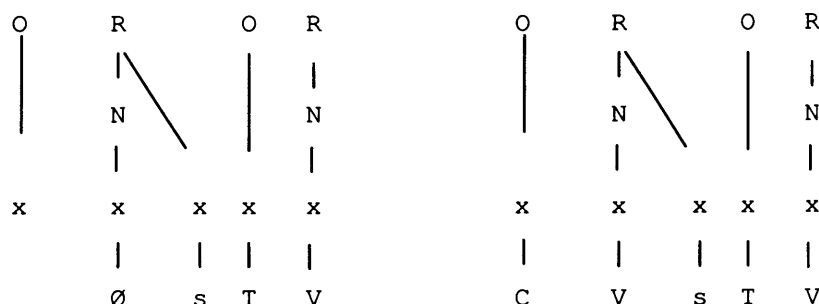
Small oval: conditions for word medial sT

Large oval: conditions for word initial sT

The relevant structures are given below. Word medial sT (41b) involves a branching rhyme, and word initial sT (41a) both a branching rhyme and a 'magic' empty nucleus.

## 41. a. Word initial sT (Pan 2005)

## b. Word medial sT (Pan 2005)



The prediction made by the Government Phonology model proposed by Pan is therefore that word medial sT clusters are acquired before word initial sT clusters.

Pan's developmental prediction tallies with the existence of an implicational universal regarding initial and medial sT clusters in language typology. Specifically, there are languages that allow sT clusters in both word initial and word medial position (e.g. Greek, English), languages that allow sT clusters in word medial position only (e.g. Spanish), and no languages, to my knowledge, that allow sT clusters in word initial position only. Such typology is consistent with the assumption that the requirements for word initial sT form a proper subset of those for word medial sT.

Interestingly, Pan (2005) does not test this prediction. In fact, she does not seem to realise that such prediction follows from her proposal. Instead, she pursues a different avenue altogether. Precisely, she claims that the model she proposes predicts that initial sT clusters are acquired after codas and she tests the prediction on data from children with phonological delays, with positive results.

However, there is a flaw in the argumentation, revealing an inconsistency within the system she proposes. The prediction that initial sT is acquired after codas is made under the assumption that the requirements for codas are a proper subset of those for initial sT. This assumption is not consistent with the model. In the coda category (branching rhyme in her terminology) she includes word medial clusters (e.g. *dolphin*, *doctor*), as well as word final ones (e.g. *lamp*, *belt*). The problem lies with the word final ones, which are indeed codas (coda-onset clusters) in the Government Phonology analysis she adopts (and thus require a marked setting of the Branching rhyme parameter), but which also involve a final empty nucleus, thus requiring a marked setting of the Final empty nucleus parameter as well (see chapter

1, section 4.3). The requirements for word final clusters are thus not a subset of those for word initial sT, within the system she proposes: instead, they form an intersection.

Therefore, comparing the acquisition of initial sT to that of word medial codas (the requirements of which form a subset relation to those of sT) and word final clusters (the requirements of which form an intersection to those of sT) combined is, at best, not insightful<sup>9</sup>.

## 4.2 Goal of the experiment

The goal of this experiment is to examine the acquisition of word initial versus word medial sT clusters, and more specifically, to test the prediction made by the model proposed by Pan (2005) that sT is acquired in word medial position before its acquisition in word initial position, versus the prediction made by the CVCV model that there is no difference in the acquisition of sT in the two positions.

The experimental hypothesis,  $H_1$ , is that children's performance of sT in word medial position will be better than in word initial position. The null hypothesis,  $H_0$ , is that there will be no difference in performance between the two positions.

- |     |       |           |                       |
|-----|-------|-----------|-----------------------|
| 42. | $H_1$ | #sT < -sT | < worse performance   |
|     | $H_0$ | #sT = -sT | = similar performance |

## 4.3 Methods and materials

This experiment consists of two conditions, a word initial sT condition and a word medial sT condition. The word initial sT condition was described earlier in this chapter (section 2). Information on subjects, materials, methodology and procedure can be found in section 2.3. In both conditions, a non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children. The children were asked to repeat words that contained the target cluster.

The clusters tested in both conditions were the following:

43. *sp, st, sk, sf, sx.*

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<sup>9</sup> Note that Pan claims that a marked setting of the Branching rhyme parameter implies a marked setting of the Final empty nucleus parameter. See, however, chapter 2, section 5.3.

Some (real) Greek words containing these clusters in word medial position are listed in 44. For examples of clusters in word initial position, see section 2.3.

44. *'espasa* ‘break’ PAST.1<sup>ST</sup> SG  
*mistik'o* ‘secret’  
*fr'esko* ‘fresh’  
*'esfaksa* ‘slaughter’ PAST.1<sup>ST</sup> SG  
*p'asxa* ‘easter’

The words used in the word medial condition, were the mirror images of the words used in the word initial condition (45). The target cluster always precedes the stressed vowel.

45. #sT *sp'oki*, *st'ipo*, *sk'api*, *sf'ito*, *sx'ika*  
 -sT *kisp'o*, *post'i*, *pisk'a*, *tosf'i*, *kasx'i*

## 4.4 Results

### 4.4.1 General results

The categories used for coding in the word medial sT condition were the same as the ones used in the previous experiments (see section 2.4.1). Table 5 shows the categories with an example for each, followed by some more examples (46-51).

Code	Stimulus	Response
Correct	<i>kasx'i</i>	<i>kasx'i</i>
Drops 1 <sup>st</sup>	<i>kisp'o</i>	<i>kip'o</i>
Drops 2 <sup>nd</sup>	<i>kasx'i</i>	<i>kasi</i>
Other single	<i>post'i</i>	<i>topi</i>
Change one	<i>kisp'o</i>	<i>kist'o</i>
Other	<i>kisp'o</i>	<i>kips'o</i>

Table 5. Categories used in coding with examples of corresponding responses

46. Correct clusters

*kasx'i* → *kasx'i* (Mirto 3;00)

*kisp'o* → *skisp'o* (Antonia 2;11,20)

*pisk'a* → *pisk'a* (Sofia 3;01)

47. Drops 1<sup>st</sup>

*kisp'o* → *kip'o* (Elisavet 3;07,14)

*tosf'i* → *tof'i* (Manthos 3;00,19)

*pisk'a* → *pik'a* (Vagelio 2;10,07)

48. Drops 2<sup>nd</sup>

*kasx'i* → *kas'i* (Agelos 3;04,12)

*kasx'i* → *xas'i* (Emanouil 2;10,20)

49. Other single

*post'i* → *top'i* (Manouela 2;11 )

*tosf'i* → *xtoθ'i* (Nikolas 2;10)

50. Change one

*kisp'o* → *kist'o* (Sofia 3;01)

*kasx'i* → *kask'i* (Maraki 3;05)

51. Other

*kisp'o* → *kips'o* (Epistimi 2;03)

*kasx'i* → *karts'i* (Thanos 3;11)

The results for word medial sT are given in figure 8. The complete results are given in the appendix.



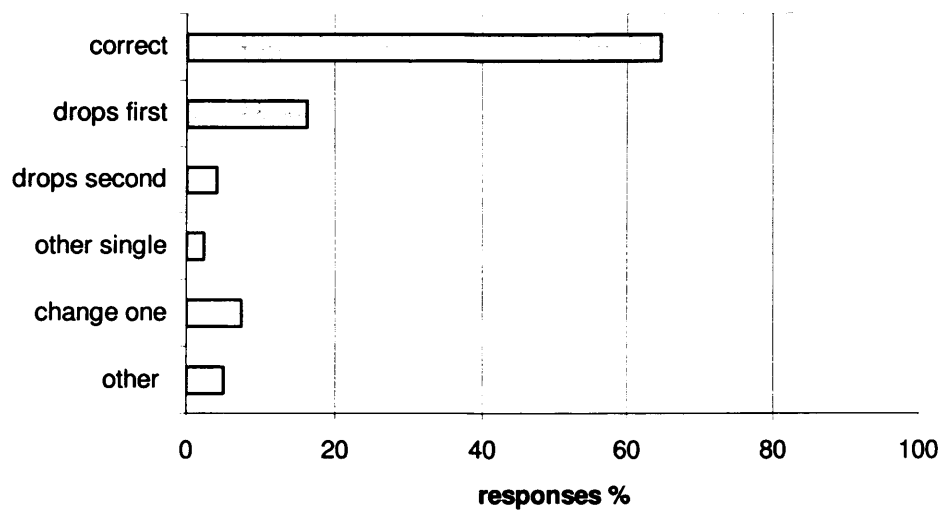


Fig. 8 Word medial sT clusters (n=294), percentage of responses by category for all children combined

Target responses represented around 65 percent of the total responses. The most common mistake was deletion of the first consonant, while the second consonant was dropped less often. There was a significant difference between dropping of the first and the second consonant ( $\chi^2=21.600$ ,  $DF=1$ ,  $p<0.001$ ).

Dropping of the first versus second consonant was also compared separately for the s+stop (*sp*, *st*, *sk*) and s+fricative (*sf*, *sx*) cluster sub-categories. Figure 9 shows the percentage of deletion of the first consonant (*s*) for the two sub-categories (for results see appendix).

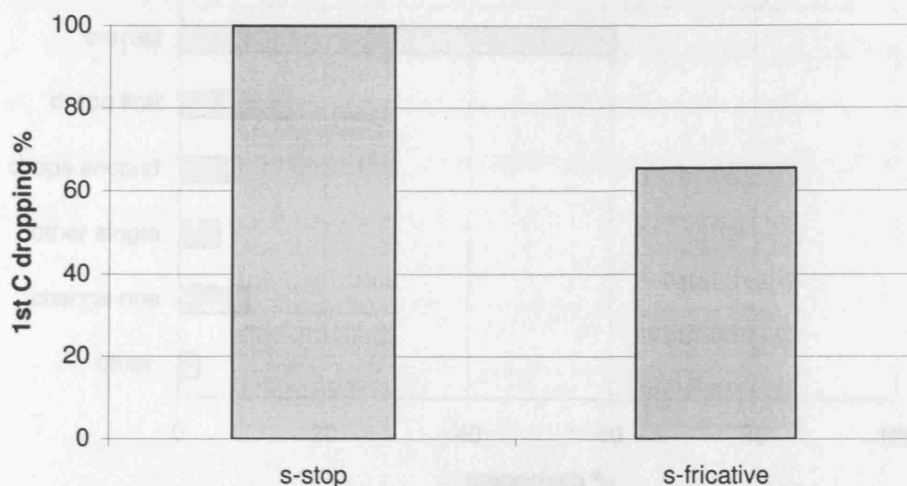


Fig. 9. Word medial sT: percentage of dropping of the first consonant (*s*) in reduced clusters by cluster sub-category (*s*-stop and *s*-fricative clusters) for all children combined

#### 4.4.2 sT versus sT

In the *s*-stop sub-category the *s* was dropped one hundred percent of the time, while in the *s*-fricative sub-category it was dropped far less often. A one variable chi-square was performed to test whether there was a statistically significant difference between dropping of the *s* and dropping of the fricative in the *s*-fricative sub-category. The  $\chi^2$  value of 3.457 had an associated probability value of  $p=0.063$ ,  $DF=1$ , showing no significant difference between dropping of the *s* and the fricative in this sub-category.

In sum, according to our results, in fricative-stop (*s*-stop) clusters, the fricative (*s*) was dropped more often, while in fricative-fricative (*s*-fricative) clusters, no difference was found between dropping of the first (*s*) and dropping of the second fricative.

Detailed results for the word initial sT condition were presented in section 2.4.1. Correct responses were given around 60% of the time. The relevant figure is repeated below.

Fig. 11. Percentage of correct responses for word medial sT versus word initial sT clusters for all children combined

A chi-square test was carried out to discover whether there was a significant relationship between position (word initial versus word medial) and performance (number of correct responses). The  $\chi^2$  value of 1.225 had an associated probability

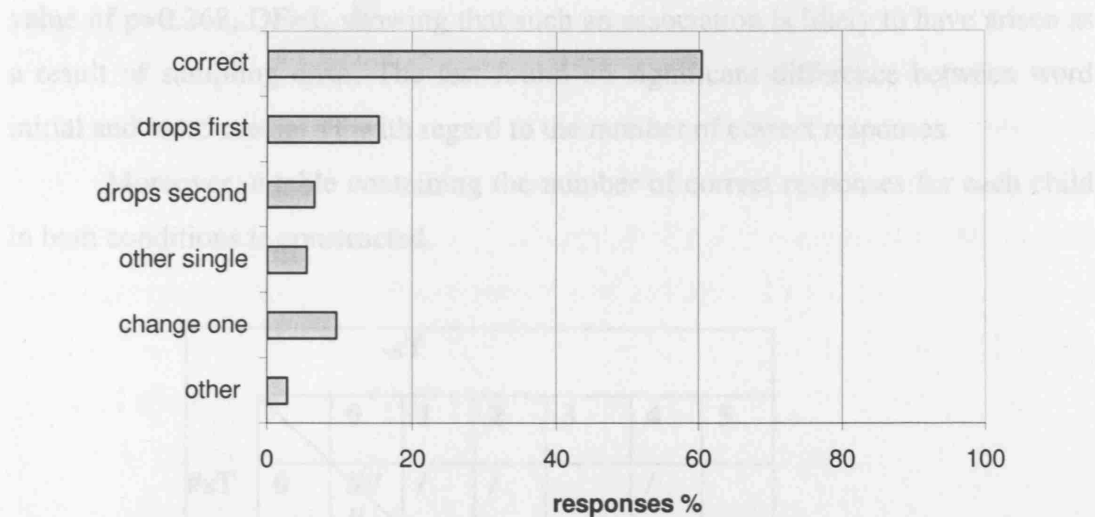


Fig. 10. Word initial sT clusters (n=293), percentage of responses by category for all children combined

#### 4.4.2 #sT versus -sT

The percentage of target responses is similar in the two conditions. As seen in figure 11, children responded correctly around 60 percent of the time in both cases.

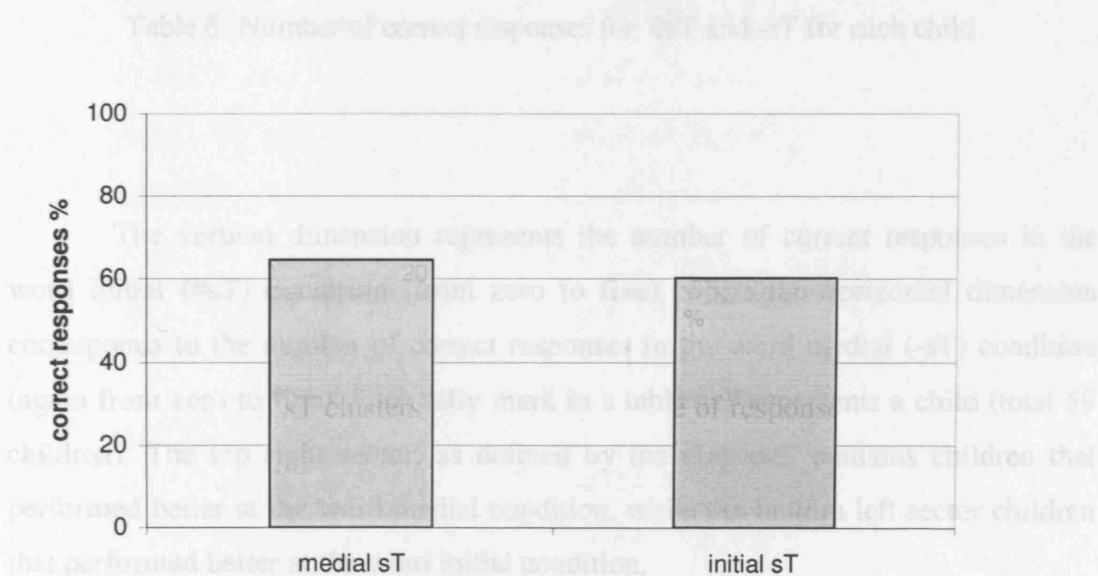


Fig. 11. Percentage of correct responses for word medial sT versus word initial sT clusters for all children combined

A chi-square test was carried out to discover whether there was a significant relationship between position (word initial versus word medial) and performance (number of correct responses). The  $\chi^2$  value of 1.225 had an associated probability

value of  $p=0.268$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. The test found no significant difference between word initial and word medial sT with regard to the number of correct responses.

Moreover, a table containing the number of correct responses for each child in both conditions is constructed.

		-sT					
#sT		0	1	2	3	4	5
	0	/// //	/	/		/	
	1	//		/	/	/	
	2			/	/	//	
	3			/	///	///	
	4			/	//// ///	/// ///	/// //
	5					//	/// ///

Table 6: Number of correct responses for #sT and -sT for each child

The vertical dimension represents the number of correct responses in the word initial (#sT) condition (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the word medial (-sT) condition (again from zero to five). Each tally mark in a table cell represents a child (total 59 children). The top right sector, as defined by the diagonal, contains children that performed better at the word medial condition, while the bottom left sector children that performed better at the word initial condition.

We expect that the top right sector will contain a greater number of children; more children will perform better at word medial sT than at word initial sT. The bottom left sector should be almost empty.

A one-variable chi-square test was performed, to test the difference between the two sectors. A  $\chi^2$  value of 0.714 had an associated probability value of  $p=0.398$ ,  $DF=1$ . There is no statistically significant difference between the two sectors. No

significant difference was found in the number of children that performed better at either of the two conditions. Some examples of individual children's performance are listed in 52a-c below. Emanouela (52a) performed adult-like in both conditions, while Epistimi (52b) did not give any correct responses in either condition. Finally, Maraki's performance (52c) was between that of the two previous children, with two correct responses (out of five trials) in each condition.

52. a. Emanouela (4;11,21)

#sT: 5 out of 5 target

*sk'api* → *sk'api*

*sp'oki* → *sp'oki*

*st'ipo* → *st'ipo*

*sf'ito* → *sf'ito*

*sx'ika* → *sx'ika*

-sT: 5 out of 5 target

*pisk'a* → *pisk'a*

*kisp'o* → *kisp'o*

*post'i* → *post'i*

*tosf'i* → *tosf'i*

*kasx'i* → *kasx'i*

b. Epistimi (2;03,08)

#sT: 0 out of 5 target

*sp'oki* → *p'oki*

*st'ipo* → *s'ipo*

*sk'api* → *k'api*

*sx'ika* → *s'ika*

*sf'ito* → *p<sup>h</sup>'ipo*

-sT: 0 out of 5 target

*pisk'a* → *pijk'a*

*kisp'o* → *kips'o*

*post'i* → *ku<sup>t</sup>'i*

*tosf'i* → *tof'i*

*kasx'i* → *kak'i*

c. Maraki (3;05,03)

#sT: 2 out of 5 target

*sp'oki* → *sp'oki*

*sk'api* → *sk'api*

*st'ipo* → *t'ipo*

*sx'ika* → *s'ika*

*sf'ito* → *θ'ito*

-sT: 2 out of 5 target

*pisk'a* → *pisk'a*

*post'i* → *post'i*

*kisp'o* → *kip'o*

*tosf'i* → *sof'i*

*kasx'i* → *kask'i*

A visual examination of table 6 reveals an imbalance, which might have affected the result of the statistical test. Specifically, there is a high concentration of tally marks around the bottom right corner, indicating that our sample includes a high number of children that were very advanced in sT cluster production. This concentration of advanced – in both conditions – children may have overshadowed the results coming from children in earlier stages of sT acquisition, and given overall results of no difference between the two conditions, while in fact there exists one in earlier stages of acquisition.

In order to control for this, I divide the children into three age groups so that the performance of younger children can be examined separately. Group 1 contains the youngest children (covering one-year age difference starting with the youngest one 2;03-3;05 n=24), group 3 the oldest children (one-year age difference 4;00-5;00 n=17) and group 2 the children between the two other groups (3;06-3;11 n=18). Figure 12 contains the percentage of correct responses for the two positions by age group (for results table see appendix).

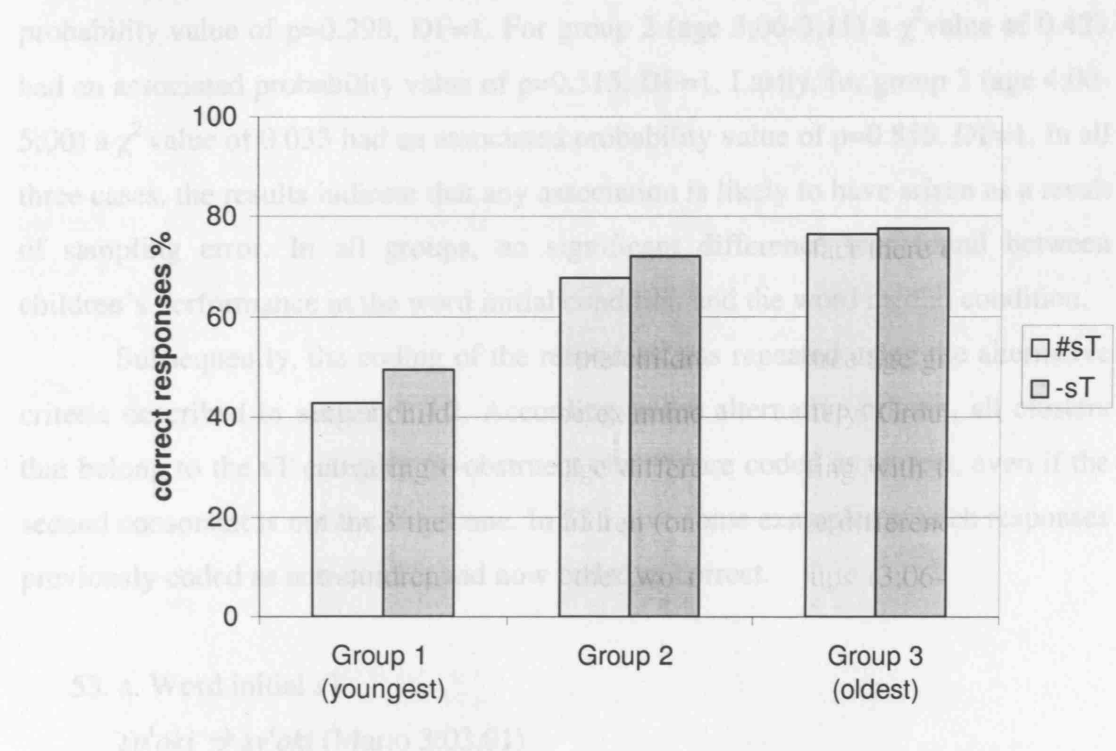


Figure 12. Percentage of correct responses for word initial versus word medial sT by age group

The assumption behind this decision is that older children perform better than younger ones. This assumption (hypothesis) can be tested with a two variable chi-

square test that examines whether there is an association between age group and performance. In word initial position, a  $\chi^2$  value of 26.488 had an associated probability value of  $p < 0.001$ ,  $DF=2$ . In word medial position, the  $\chi^2$  value of 20.360 similarly had an associated probability value of  $p < 0.001$ ,  $DF=2$ . The results in both positions show that such an association is extremely unlikely to have arisen as a result of sampling error. A look at the results, figure 12, shows that the association follows the expected direction; in both word initial and word medial position, performance improves with age. The results of group 3, the oldest group, are better than the results of group 2, which, in turn, are better than the results of group 1, the youngest group, in both positions.

After having checked that our assumption that older children perform better, is correct, we can proceed to test whether there is a difference between word initial and word medial position in each age group. In each case, a chi-square test was performed to examine whether there is an association between position and performance. For group 1 (age 2;03-3;05) a  $\chi^2$  value of 1.082 had an associated probability value of  $p=0.298$ ,  $DF=1$ . For group 2 (age 3;06-3;11) a  $\chi^2$  value of 0.423 had an associated probability value of  $p=0.515$ ,  $DF=1$ . Lastly, for group 3 (age 4;00-5;00) a  $\chi^2$  value of 0.033 had an associated probability value of  $p=0.855$ ,  $DF=1$ . In all three cases, the results indicate that any association is likely to have arisen as a result of sampling error. In all groups, no significant difference was found between children's performance in the word initial condition and the word medial condition.

Subsequently, the coding of the responses was repeated using the alternative criteria described in section 2.4.2. According to the alternative criteria, all clusters that belong to the sT category (s+obstruent cluster) are coded as correct, even if the second consonant is not the target one. In 53 I give some examples of such responses previously coded as non-correct and now coded as correct.

#### 53. a. Word initial sT

*sp'oki* → *sv'oki* (Mario 3;03,01)

*sx'ika* → *sk'ika* (Mirto 3;00)

#### b. Word medial sT

*tosf'i* → *stosp'i* (Argiroula 3;04,01)

Fig. 1 *kisp'o* → *pist'o* (Manthos 3;00,19)

Moreover, under the alternative criteria, responses involving an alteration of *s* (a *θ* pronunciation) are not coded as correct, even if the child performs this alteration consistently when producing *s* as a single consonant. Some examples of responses coded as correct under the original criteria and now (under the alternative criteria) coded as non correct are given in 54a for word initial *sT* and 54b for word medial *sT* (see also section 2.4.2).

#### 54. a. Word initial *sT*

*st'ipo* → *θt'ipo* (Kali 3;00)  
*st'ipo* → *θt'ipo* (Fenia 3;01)

#### 4.5 b. Word medial *sT*

*pisk'a* → *kiθk'a* (Kali 3;00)  
*pisk'a* → *piθk'a* (Fenia 3;01)

Following the alternative criteria, there is a 4.8% increase of responses coded as correct in the word initial condition, and a 0.4% increase in the word medial condition, when compared to the results under the original criteria. Figure 13 shows the percentages of correct responses in the two conditions (for raw numbers see appendix).

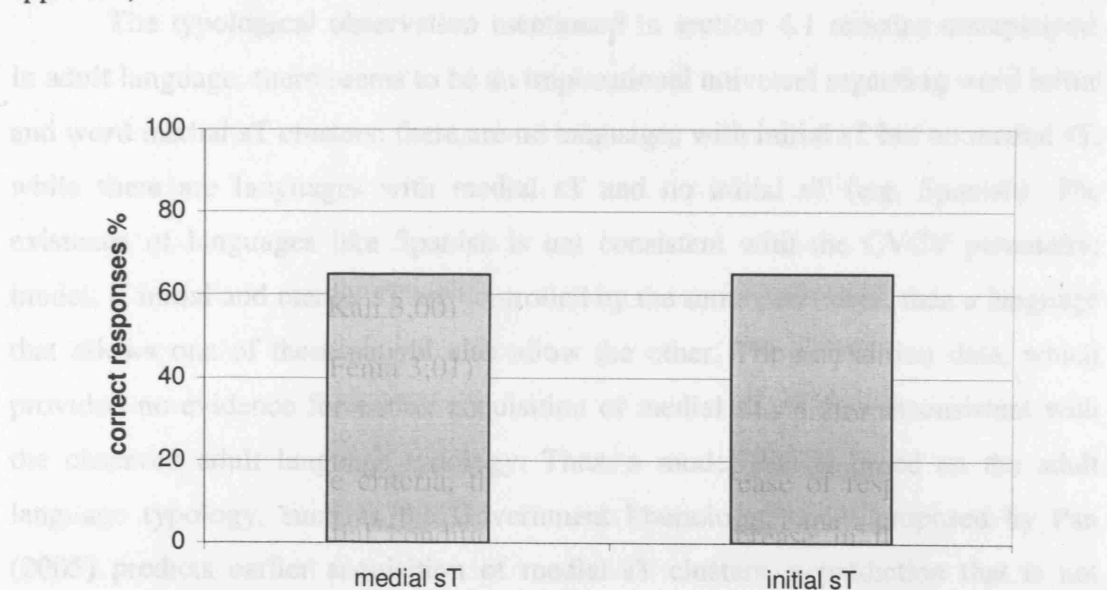




Fig. 13. Percentage of correct responses for word medial versus word initial sT clusters for all children combined, according to alternative criteria

As before, a chi-square test was carried out to discover whether there was a significant relationship between position (initial versus medial) and performance (number of correct responses). The  $\chi^2$  value of 0.003 had an associated probability value of  $p=0.955$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. Under the new criteria, no difference between word initial and word medial sT was found either.

To sum up, no examination of the data and no statistical test found any difference between children's performance in the word initial sT condition and their performance in the word medial sT condition.

#### 4.5 Analysis

The results do not provide support for the experimental hypothesis. Contrary to the prediction of the Government Phonology model proposed by Pan (2005), there was no evidence that word medial sT is acquired before word initial sT.

In contrast, the prediction made by the CVCV model proposed here is consistent with the findings. The model assumes identical requirements in terms of marked parameter settings for sT clusters in the two positions. Therefore, no difference in their acquisition is expected. This is consistent with the findings of this experiment.

The typological observation mentioned in section 4.1 remains unexplained. In adult language, there seems to be an implicational universal regarding word initial and word medial sT clusters: there are no languages with initial sT but no medial sT, while there are languages with medial sT and no initial sT (e.g. Spanish). The existence of languages like Spanish is not consistent with the CVCV parametric model: if initial and medial sT are controlled by the same parameter, then a language that allows one of them should also allow the other. The acquisition data, which provided no evidence for earlier acquisition of medial sT, is also inconsistent with the observed adult language typology. Thus, a model that is based on the adult language typology, such as the Government Phonology model proposed by Pan (2005) predicts earlier acquisition of medial sT clusters, a prediction that is not

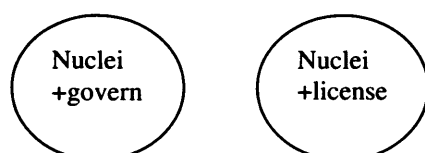
supported by our experimental results. I have nothing insightful to say on this issue and I shall leave it for future research.

## 5 -sT versus -TR

### 5.1 The prediction

A further prediction made by the CVCV parametric model concerns the order of acquisition of word medial sT versus word medial TR. These two cluster types are controlled by two independent parameters (Nuclei+/-govern the former, Nuclei+/-license the latter). Each cluster type requires a marked setting of the respective parameter. The requirements of the two thus form two independent sets.

#### 5.1.1 Two independent sets



Left oval: requirements for -sT

Right oval: requirements for -TR

This analysis predicts that there will be variation in the order of acquisition of these clusters. Specifically, some children will acquire sT before TR and some TR before sT. No overall bias is expected in either direction.

However, it is argued that there exists a typological universal concerning complex onsets and codas, which is inconsistent with the assumption that government and licensing are independent. Precisely, it is argued that the presence of a complex onset in a language implies the presence of a coda in that language. There are languages that allow both structures (e.g. English and Greek), and languages that allow codas but no complex onsets (e.g. Hungarian), while there are no languages that allow complex onsets but no codas (Kaye & Lowenstamm 1981).

Various models in different frameworks have been proposed in order to capture this universal (see e.g. Baertsch & Davis (2003), Cyran (2003), Kaye & Lowenstamm (1981)). For example, Kaye & Lowenstamm (1981) formalise the typological observation as a constraint on structure: if a language allows a marked

onset (i.e. branching onset) then it allows a marked rhyme (i.e. branching rhyme). Moreover, Cyran (2003) stipulates an implicational relationship regarding government and licensing: if, in a language, nuclei can license (formation of TR clusters), then they also have the ability to govern (formation of coda-onset clusters). Note that these assumptions do not follow from any theoretical necessity, they are stipulations made solely in order to capture the typological observations.

In first language acquisition, if we adopt Cyran's (2003) suggestion that there exists an implicational relationship between government and licensing, then we predict that word medial sT (involving government) is acquired before word medial TR, which is controlled by licensing.

## 5.2 Goal of the experiment

The goal of this experiment is to examine the acquisition of word medial sT versus word medial TR clusters, and more specifically, to test the prediction made by the model proposed by Cyran (2003) that acquisition of sT precedes acquisition of TR.

The experimental hypothesis,  $H_1$ , is that children's performance in word medial sT will be better than in word medial TR. The null hypothesis,  $H_0$ , is that there will be no difference in the performance of the two cluster types.

56.	$H_1$	-TR < -sT	< worse performance
	$H_0$	-TR = -sT	= similar performance

## 5.3 Methods and materials

The data used in this test consists of two parts: firstly, data from children's production of medial sT clusters, presented in section 4. Secondly, data of the same children's production of medial TR clusters, presented in chapter 3, section 3. Information on subjects, methodology, materials and procedure can be found in section 4.3 and chapter 3, section 3.3 respectively. In both cases, a non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children.

## 5.4 Results

Detailed results for both cluster types are given in sections 4.4 for sT and chapter 3, section 3.4 for TR. Figure 14 below shows the percentage of correct responses for each of the clusters.

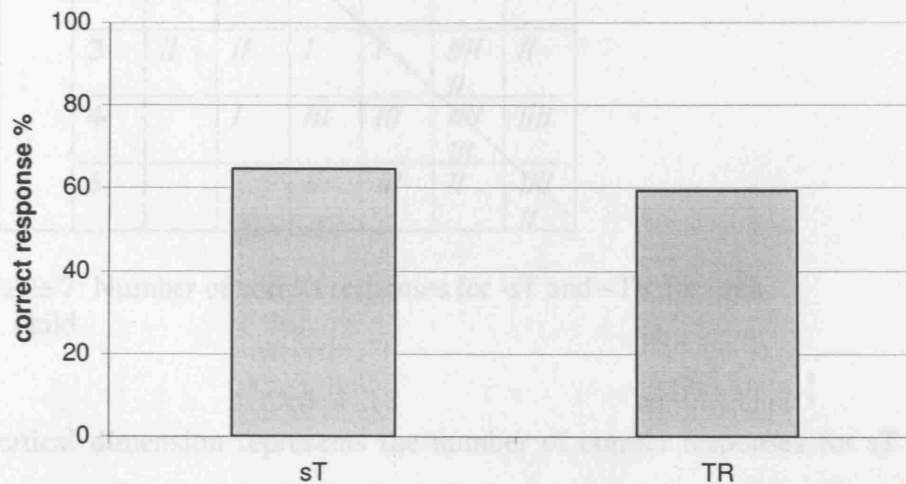


Fig 14. Percentage of correct responses for sT versus TR clusters in word medial position for all children combined

The percentages are very close; there seems to be no major difference in either direction. A chi-square test was carried out to discover whether there was a significant relationship between cluster type (sT versus TR) and performance. The  $\chi^2$  value of 1.758 had an associated probability value of  $p=0.185$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. No significant difference was found between sT and TR with regard to the number of correct responses.

Moreover, a table containing the number of correct responses for each child for both cluster types (sT and TR) was constructed.

		-TR					
-sT		0	1	2	3	4	5
	0	//	////		//		
	1		/				
	2	//		//		/	
	3	//	//	/	/	////	//
	4		/	///	///	//// ///	///
	5			//	///	//	//// //

Table 7: Number of correct responses for -sT and -TR for each child

The vertical dimension represents the number of correct responses for sT clusters (from zero to five), while the horizontal dimension corresponds to the number of correct responses for TR clusters (again from zero to five). Each tally mark in a cell corresponds to a child. The top right sector, as defined by the diagonal, contains children that performed better at TR, while the bottom left sector contains children that performed better at sT.

A visual examination of the table does not reveal any obvious difference; the number of tally marks is roughly the same in the two sectors. In order to test whether our visual judgment finds statistical support, a one-variable chi-square test was carried out, testing the difference between the two sectors. A  $\chi^2$  value of 0.100 had an associated probability value of  $p=0.752$ ,  $DF=1$ . No statistically significant difference was found between the number of children that performed better at sT and those that performed better at -TR.

Moreover, the table shows variation in children's performance: some children performed better at one of the two cluster categories, while some children had the same performance for both cluster types. Some examples of the diversity are given below. Marilena (57a) performed better at sT than at TR, while Antonia (57b) performed (slightly) better at TR than at sT. Antonia's overall performance was slightly better than Marilena's, while Dionisia's performance (57c) was adult-like in both cluster categories.

57. a. Marilena (3;10)

- sT: 3 out of 5 target

*tosf'i* → *tosf'i*

*post'i* → *post'i*

*pisk'a* → *pisk'a*

*kasx'i* → *kas'i*

*kisp'o* → *sip'o*

-TR: 1 out of 5 target

*tokl'i* → *kli*

*povr'i* → *pov'i*

*pifl'a* → *pif'a*

*kixr'o* → *ksix'o*

*katr'i* → *klatl*

b. Antonia (2;11,20)

- sT: 3 out of 5 target

*kisp'o* → *skisp'o*

*tosf'i* → *sfi*

*post'i* → *post'i*

*kasx'i* → *ksi*

*pisk'a* → *piθk'a*

-TR: 4 out of 5 target

*tokl'i* → *tokl'i*

*povr'i* → *povr'i*

*pifl'a* → *pixt'a*

*kixr'o* → *kixr'o*

*katr'i* → *katr'i*

c. Dionisia (4;06,01)

-sT: 5 out of 5 target

*pisk'a* → *pisk'a*

*kisp'o* → *kisp'o*

*post'i* → *post'i*

*kasx'i* → *kasx'i*

*tosf'i* → *tosf'i*

-TR: 5 out of 5 target

*tokl'i* → *tokl'i*

*povr'i* → *povr'i*

*pifl'a* → *fl'a*

*kixr'o* → *kixr'o*

*katr'i* → *kakr'i*

A visual examination of table 7 reveals an imbalance in the results. Specifically, there is a high concentration of tally marks around the bottom right corner. This indicates that a high percentage of children performed very well at both cluster types. This concentration of advanced – in both conditions – children may have overshadowed the results coming from children in earlier stages of acquisition, who may – or may not – exhibit a difference between the two cluster types.

In order to control for this, I divide the children into three age groups (group 1: 2;03-3;05 n=24, group 2: 3;06-3;11, n=18, group 3: 4;00-5;00 n=17) so that the performance of younger children can be examined separately. The percentages of correct responses for the two positions by age group are given in figure 15 (for detailed results see appendix).

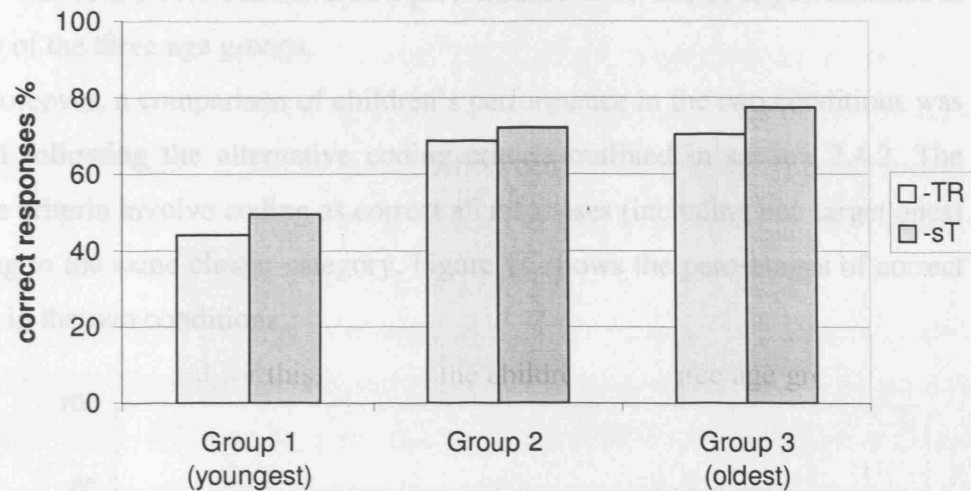


Figure 15. Percentage of target responses for word medial TR versus word medial sT by age group

The assumption behind this decision is that performance improves with age. This assumption (hypothesis) was tested with a two variable chi-square test that examines whether there is an association between age group and performance. The statistically significant results of the test for sT ( $\chi^2=20.360$ ,  $p=0.001$ ,  $DF=2$ ) and for TR ( $\chi^2=19.306$ ,  $p<0.001$ ,  $DF=2$ ) show that such an association is extremely unlikely to have arisen as a result of sampling error. Figure 15 reveals that the association follows the expected direction; performance in both sT and TR improves with age. The results of group 3, the oldest group, are better than the results of group 2, which, in turn, are better than the results of group 1, the youngest group, in both cluster types.

Having checked that the assumption that performance improves with age is correct, we can test whether there is a difference between sT and TR in each age group. In each case, a chi-square test was performed to examine whether there is an

association between position and performance. For group 1 (age 2;03-3;05) a  $\chi^2$  value of 0.703 had an associated probability value of  $p=0.402$ ,  $DF=1$ . For group 2 (age 3;06-3;11) a  $\chi^2$  value of 0.241 had an associated probability value of  $p=0.624$ ,  $DF=1$ . Lastly, for group 3 (age 4;00-5;00) a  $\chi^2$  value of 1.104 had an associated probability value of  $p=0.293$ ,  $DF=1$ . In all three cases, the results show that any association is likely to have arisen as a result of sampling error. No significant difference was found between children's performance at sT and their performance at TR in any of the three age groups.

Moreover, a comparison of children's performance in the two conditions was performed following the alternative coding criteria outlined in section 2.4.2. The alternative criteria involve coding as correct all responses (including non target ones) that belong to the same cluster category. Figure 16 shows the percentages of correct responses in the two conditions.

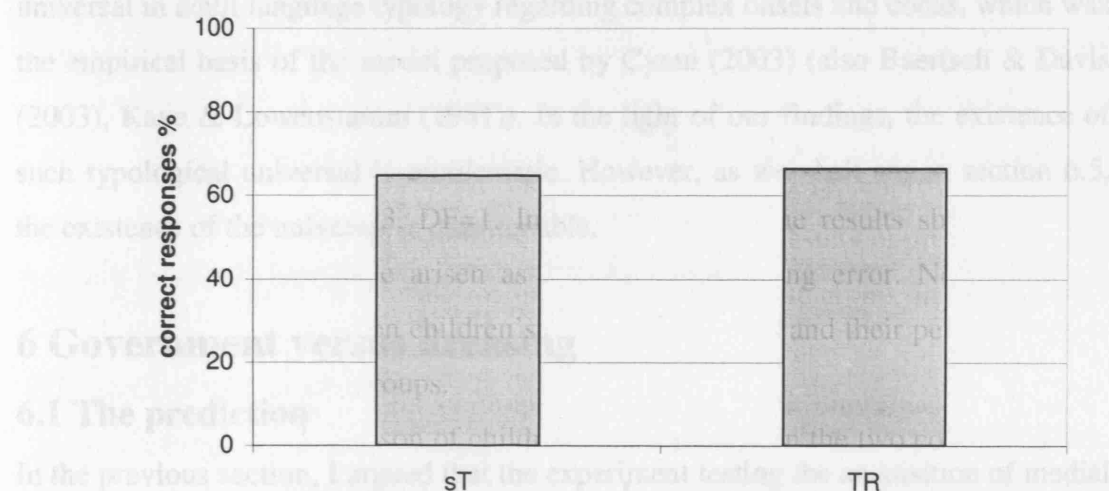


Fig. 16. Percentage of correct responses for word medial sT versus word medial TR clusters for all children combined, according to alternative criteria

The figure reveals great similarity of performance in the two conditions. A chi-square test was carried out to discover whether there was a significant relationship between position (initial versus medial) and performance (number of correct responses). The results ( $\chi^2=0.142$ ,  $p=0.706$ ,  $DF=1$ ) do not show a statistically significant difference between TR and sT.



In sum, no examination of the data revealed any difference between children's performance in the word medial sT condition and their performance in the word medial TR condition.

## **5.5 Analysis**

The results do not provide support for the experimental hypothesis. Contrary to the prediction of the model proposed by Cyran (2003), there was no evidence that word medial sT is acquired before word medial TR. Cyran's suggestion that there is an unidirectional implication regarding government and licensing (licensing implies government), found not support in the acquisition data. The findings were consistent with the view proposed here that government and licensing are independent parameters.

The acquisition results are inconsistent with the existence of an implicational universal in adult language typology regarding complex onsets and codas, which was the empirical basis of the model proposed by Cyran (2003) (also Baertsch & Davis (2003), Kaye & Lowenstamm (1981)). In the light of our findings, the existence of such typological universal is problematic. However, as we shall see in section 6.5, the existence of the universal is questionable.

## **6 Government versus licensing**

### **6.1 The prediction**

In the previous section, I argued that the experiment testing the acquisition of medial sT and TR did not provide support for Cyran's (2003) proposal that there exists an implicational relationship between government and licensing. However, the experiment examined the acquisition of only one cluster type that is controlled by government, namely sT clusters. It could be the case that children who were more advanced in TR than sT had in fact acquired other types of government clusters, and did not produce sT clusters for independent reasons (for some kind of segmental-melodic reasons, as opposed to structural reasons). It is therefore possible that the implication suggested by Cyran holds, but was not detected by the test.

It is thus crucial to compare the acquisition of TR clusters (licensing clusters) to the acquisition of government clusters of several types combined. This will be an appropriate test of the implicational relationship. The prediction is that clusters

involving government will be acquired before clusters involving licensing. In phonological lingua franca, this means that codas will be acquired before complex onsets.

Note that part of the motivation behind models like Cyran's is the developmental pattern reported in previous acquisition studies with regard to the order of acquisition of codas and complex onsets (Levelt & van de Vijver 2004; Levelt, Schiller, & Levelt 2000). For example, Baertsch & Davis (2003) set out to account for the implicational universal in adult language typology as well as for the developmental pattern whereby the acquisition of codas precedes that of complex onsets. With regard to the latter, they quote Levelt, Schiller & Levelt (2000), who report that CV syllables appear first in acquisition, followed by CVC and finally CCV syllables.

The CVCV model proposed here expects no bias in either direction in the acquisition of codas and complex onsets. Word medial TR clusters require one marked setting (Nuclei+license). Clusters that correspond to 'codas' (i.e. word medial RT, TT, sT) are controlled by government, requiring again one (but different) marked setting (Nuclei+govern). There is no theoretical reason to assume an implicational relationship between the two parameters (government and licensing) and thus no reason to expect any bias in the acquisition of the respective clusters.

## 6.2 Goal of the experiment

The goal of this experiment is to examine the acquisition of word medial sT clusters versus word medial TR clusters, and more specifically, to test the prediction made by the model proposed by Cyran (2003) that acquisition of branching rhymes (sT, TT, RT) precedes acquisition of complex onsets (TR).

The experimental hypothesis,  $H_1$ , is that children's performance in word medial sT, TT and RT combined will be better than in word medial TR. The null hypothesis,  $H_0$ , is that there will be no difference in the performance of the two cluster types.

- |     |       |                     |                       |
|-----|-------|---------------------|-----------------------|
| 58. | $H_1$ | -TR < -sT, -TT, -RT | < worse performance   |
|     | $H_0$ | -TR = -sT, -TT, -RT | = similar performance |

## 6.3 Methods and materials

### 6.3.1 General

The data used in this test consists of two conditions. Firstly, the Licensing condition involves data from Greek children's production of word medial TR clusters, presented in chapter 3, section 3. Secondly, the Government condition involves data from the same children's production of word medial TT clusters (chapter 3, section 2), sT clusters (section 5) and word medial RT clusters (presented in the following section). Information on subjects, methodology, materials and procedure can be found in the corresponding sections.

### 6.3.2 RT clusters

Subjects, methodology and procedure were the same as in the previous experiments (chapter 3, sections 2.3.1, 2.3.2, 2.3.4 respectively). A non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual Greek children. Children were asked to repeat words that contained the target cluster and their responses were recorded, transcribed and analysed.

The stimuli used contained sonorant-obstruent (RT) clusters in word medial position. The clusters tested have either *r* or *l* as first member and either a stop or a fricative as second member. The clusters are listed below:

59. *rt, lk, rf, lt, lp*

These clusters all exist in Greek words word medially (but not word initially). Some examples follow.

60. *p<sup>l</sup>arti* 'party'

*x<sup>l</sup>alkinos* 'copper' adj.

*karf<sup>l</sup>i* 'nail'

*palt<sup>l</sup>o* 'coat'

*k<sup>l</sup>olpo* 'trick'

The non-words were designed following the same principles as for the previous experiments (see chapter 3, section 2.3.3), forming feminine or neuter nouns. All

words were disyllabic, with a voiceless stop as an onset for the non target syllable: *p*, *t* or *k*. The following words were tested:

61. *kart'i*, *tolk'i*, *porf'i*, *pilt'a*, *kilp'o*

The target cluster always preceded the stressed vowel.

Transcription was done in the same way as for the previous experiments, and it followed the same principles.

## 6.4 Results

### 6.4.1 RT clusters

The categories used for coding were the same as those used in the previous experiments. Table 8 shows the categories with an example for each, followed by some more examples (62-66).

Code	Stimulus	Response
Correct	<i>kilp'o</i>	<i>kilp'o</i>
Drops 1 <sup>st</sup>	<i>porf'i</i>	<i>pof'i</i>
Drops 2 <sup>nd</sup>	<i>pilt'a</i>	-
Other single	<i>kart'i</i>	<i>kap'i</i>
Change one	<i>kart'i</i>	<i>xak'i</i>
Other	<i>kilp'o</i>	<i>kipl'o</i>

Table 8. Categories used in coding with examples of corresponding responses

#### 62. Correct

*kilp'o* → *kilp'o* (Antonis 3;06,04)

*porf'i* → *porf'i* (Fenia 3;01,04)

*tolk'i* → *tolk'i* (Antonia 2;11,20)

#### 63. Drops 1<sup>st</sup>

*kart'i* → *kat'i* (Vasiliki 3;10,15)

*kilp'o* → *kip'o* (Fanouris 3;04,15)

*porf<sup>l</sup>i* → *pof<sup>l</sup>i* (Manos 3;04,04)

64. Other single

*kart<sup>l</sup>i* → *kap<sup>l</sup>i* (Mario 3;03,01)

*tolk<sup>l</sup>i* → *tox<sup>l</sup>i* (Fanouris 3;04,15)

*pilt<sup>l</sup>a* → *dik<sup>l</sup>a* (Mariana 3;07,17)

65. Change one

*kart<sup>l</sup>i* → *kaxt<sup>l</sup>i* (Manos 3;04,04)

*kart<sup>l</sup>i* → *xark<sup>l</sup>i* ( Despina 3;06,29)

*pilt<sup>l</sup>a* → *ixt<sup>l</sup>a* (Maria 4;06,05)

*kilp<sup>l</sup>o* → *kiθp<sup>l</sup>o* (Emanouil 2;10,20)

66. Other (different cluster, epenthesis or metathesis)

*kart<sup>l</sup>i* → *katr<sup>l</sup>i* (Elisavet 3;07,14)

*tolk<sup>l</sup>i* → *tokl<sup>l</sup>i* (Manolis 3;10,01)

*pilt<sup>l</sup>a* → *pilit<sup>l</sup>a* (Vaso 3;10,25)

*porf<sup>l</sup>i* → *pof<sup>l</sup>t<sup>l</sup>i* (Vasiliki 3;10,15)

The results for word medial RT are given in figure 17. The complete results are given in the appendix.

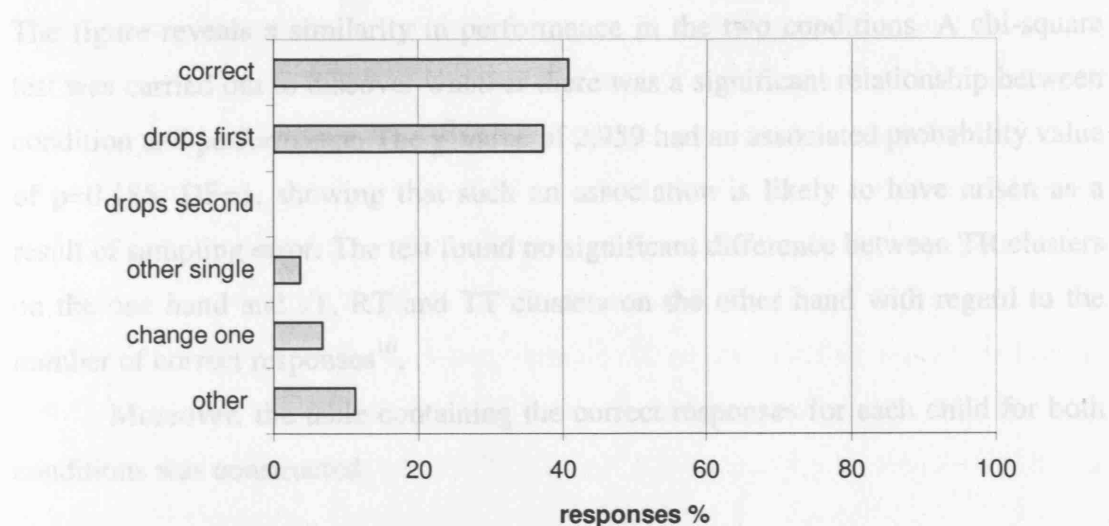


Fig. 17. Word medial RT clusters (n=294), percentage of responses by category

The percentage of correct responses was 40.8 percent. The first consonant is dropped almost as often, while the second consonant was never dropped.

#### 6.4.2 Government versus licensing

Detailed results for each of the cluster types are given in the sections mentioned above. Figure 18 below gives the percentage of correct responses for the two conditions (for results table see appendix).

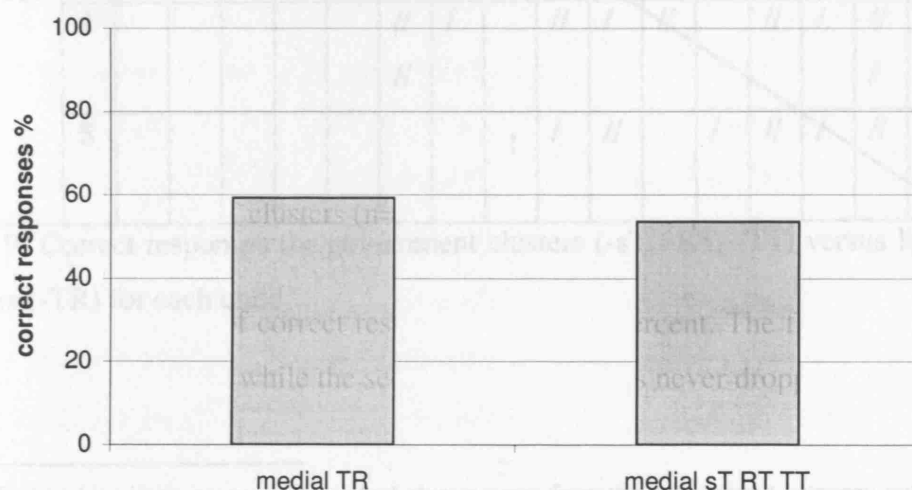


Fig 18. Percentage of correct responses for word medial TR versus word medial sT, RT and TT clusters combined for all children combined

The figure reveals a similarity in performance in the two conditions. A chi-square test was carried out to discover whether there was a significant relationship between condition and performance. The  $\chi^2$  value of 2.959 had an associated probability value of  $p=0.185$ ,  $DF=1$ , showing that such an association is likely to have arisen as a result of sampling error. The test found no significant difference between TR clusters on the one hand and sT, RT and TT clusters on the other hand with regard to the number of correct responses<sup>10</sup>.

Moreover, the table containing the correct responses for each child for both conditions was constructed.

Gov: -sT, -RT, -TT																	
Lic: -TR		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	0	//		/	//			/									
	1	//	/		/		//		/								
	/																
	2				/			//		//	/	/				/	
	3		/	/				/	/	/			/		/	/	/
	4						//	/		//	/	//		//	/	//	
						//									/		
5										/	//		/	//	/	//	//
																	/

Table 9: Correct responses for government clusters (-sT, -RT, -TT) versus licensing clusters (-TR) for each child

<sup>10</sup> We find no bias if we compare individual cluster types from the government category with the TR licensing category: TT versus TR gives  $\chi^2=0.997$ ,  $p=0.318$ ,  $DF=1$  (not statistically significant), sT versus TR (discussed in section 5) gives  $\chi^2=1.758$ ,  $p=0.185$ ,  $DF=1$  (not statistically significant). Only RT versus TR gives us a statistically significant result:  $\chi^2=20.171$ ,  $p<0.001$ ,  $DF=1$ . Interestingly, the difference is in the opposite direction to that expected, showing earlier acquisition of TR. I have no explanation to offer for this difference at this point.

The vertical dimension represents the number of correct responses in TR clusters, (from zero to five), while the horizontal dimension corresponds to the number of correct responses in the TT, sT, and RT clusters combined (from zero to fifteen). Each tally mark in a cell corresponds to a child (total fifty nine children). The top right and the bottom left sectors (divided by the diagonal line), corresponding to children that performed better at TR the former and TT, sT, RT clusters the latter, seem to be equally populated. A one-variable chi-square test that was carried out to test the difference between the two sectors<sup>11</sup> had a  $\chi^2$  value of 1.653, with an associated probability value of  $p=0.199$ ,  $DF=1$ . No statistically significant difference was found between the two sectors.

Moreover, a visual examination of the table shows variation in performance. Apart from two empty areas in the top right and bottom left corners, showing the absence of extreme differences, the tally marks are spread all over the table, indicating wide variation: some children performed a lot better in the licensing category, others in the government category, while others had comparable performance in the two categories. Some examples of children's performance are listed below. Manolio (67a) performed better at the Government than at the Licensing condition, while Aglaia (67b) exhibited the reverse pattern. Finally, Sofia (67c) gave the same percentage of correct responses in both conditions.

#### 67. a. Manolio (3;06,17)

Government: 9 out of 15 target (60%)

- sT: 4 out of 5	-TT: 2 out of 5	-RT: 3 out of 5
<i>tosf'i</i> → <i>tosf'i</i>	<i>pof't'i</i> → <i>pof't'i</i>	<i>tolk'i</i> → <i>tilk'i</i>
<i>post'i</i> → <i>kost'i</i>	<i>kaxt'i</i> → <i>kaxt'i</i>	<i>kilp'o</i> → <i>tilp'o</i>
<i>pisk'a</i> → <i>pisk'a</i>	<i>tovd'i</i> → <i>tovl'i</i>	<i>kart'i</i> → <i>xart'i</i>
<i>kisp'o</i> → <i>kisp'o</i>	<i>kiyð'o</i> → <i>ixt'o</i>	<i>porf'i</i> → <i>pof'i</i>
<i>kasx'i</i> → <i>skas'i</i>	<i>pivy'a</i> → <i>piv'a</i>	<i>pilt'a</i> → <i>tik'a</i>

<sup>11</sup> In dividing the two sectors, a ratio criterion was followed: the children that were excluded as being in the middle were those that had exactly the same ratio of correct answers in both categories (namely those in cells 0-0, 1-3, 2-6, 3-9, 4-12, 5-15). The remaining children were assigned to the sectors depending on the ratio of their correct responses for each of the two conditions.



Licensing: 2 out of 5 (40%)

-TR: 2 out of 5 target

*tokl'i* → *tokl'i*

*pifl'a* → *pifl'a*

*kixr'o* → *kix'o*

*katr'i* → *kaf'i*

*povr'i* → *pov'I*

b. Aglaia (3;03)

Government: 5 out of 15 (33.3%)

-sT: 3 out of 5

-TT: 2 out of 5

-RT: 0 out of 5

*tosf'i* → *tosf'i*

*pivy'a* → *pivy'a*

*tolk'i* → *tok'i*

*post'i* → *post'i*

*kaxt'i* → *kaxt'i*

*kilp'o* → *kip'o*

*kisp'o* → *kisp'o*

*tovd'i* → *tovd'i*

*kart'i* → *kat<sup>h</sup>i*

*pisk'a* → *piθk'a*

*kiyδ'o* → *kivg'o*

*porf'i* → *of'i*

*kasx'i* → *kak'i*

*pof*t*'i* → *post'i*

*pilt'a* → *pit<sup>h</sup>a*

Licensing: 4 out of 5 (80%)

-TR: 4 out of 5

*tokl'i* → *tokl'i*

*pifl'a* → *pifl'a*

*kixr'o* → *kixr'o*

*katr'i* → *katr'i*

*povr'i* → *povl'i*

c. Sofia (3;01)

Government: 6 out of 15 target (40%)

-sT: 2 out of 5

-TT: 3 out of 5

-RT: 1 out of 5

*pisk'a* → *pisk'a*

*pof*t*'i* → *pof*t*'i*

*pilt'a* → *pilt'a*

*post'i* → *post'i*

*kaxt'i* → *kaxt'i*

*tolk'i* → *tosfk'i*

*kisp'o* → *kist'o*

*pivy'a* → *pivy'a*

*kilp'o* → *kipl'o*

*kasx'i* → *kas'i*

*tovd'i* → *toδd'i*

*kart'i* → *kats'i*

*tosf<sup>ʰ</sup>i → tof<sup>ʰ</sup>i*

*kiyð<sup>ʰ</sup>o → kiγ<sup>ʰ</sup>o*

*porf<sup>ʰ</sup>i → pof<sup>ʰ</sup>i*

Licensing: 2 out of 5 target (40%)

-TR: 2 out of 5

*tokl<sup>ʰ</sup>i → tokl<sup>ʰ</sup>i*

*kixr<sup>ʰ</sup>o → kixr<sup>ʰ</sup>o*

*pifl<sup>ʰ</sup>a → kukl<sup>ʰ</sup>a*

*katr<sup>ʰ</sup>i → klat<sup>ʰ</sup>i*

*povr<sup>ʰ</sup>i → pov<sup>ʰ</sup>i*

Furthermore, a comparison of children's performance in the two conditions was performed following the alternative coding criteria outlined in section 2.4.2. According to the alternative criteria, all responses containing a cluster that belongs to the same category are coded as correct, even if it is not the target cluster. In the government condition this includes responses that involve a cluster that belongs to any government type cluster (sT, TT, RT). Some examples are listed below. For relevant examples in the licensing (TR) condition, see chapter 3, section 3.4.2.

68. *kart<sup>ʰ</sup>i → kaxt<sup>ʰ</sup>i* (Manos 3;04,04)

*tolk<sup>ʰ</sup>i → tolt<sup>ʰ</sup>i* (Nikos 4;03,17)

*tovð<sup>ʰ</sup>i → tolv<sup>ʰ</sup>i* (Stamatis 3;08,03)

Under the alternative criteria, there was a 7.1% increase of correct responses in the licensing condition and of 10.1% in the government condition. Figure 19 shows the percentages of correct responses in the two conditions (for results table see appendix).

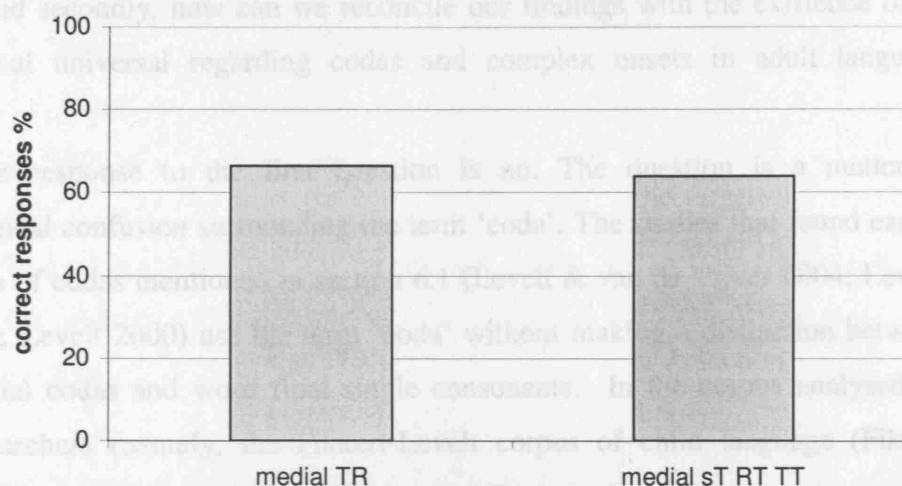


Fig. 19. Percentage of correct responses for word medial TR versus word medial sT RT and TT clusters combined for all children combined, according to alternative criteria

The figure reveals great similarity of performance in the two conditions. A chi-square test was carried out to discover whether there was a significant relationship between cluster type (government versus licensing) and performance (number of correct responses). The results ( $\chi^2=0.637$ ,  $p=0.425$ ,  $DF=1$ ), are not statistically significant, providing no evidence for a difference between government and licensing clusters.

In sum, no examination of the data revealed any difference between children's performance in the government (-sT, -TT, -RT) condition and their performance in the licensing (-TR) condition.

## 6.5 Analysis

The results do not support the experimental hypothesis. Contrary to the prediction made by Baertsch & Davis (2003), Cyran (2003) and Kaye & Lowenstamm (1981), there was no evidence that word medial codas are acquired before word medial complex onsets. The findings were consistent with the CVCV model proposed here, according to which government (which controls medial codas) and licensing (which controls complex onsets) are independent parameters.

Two questions arise here. Firstly, do our findings contradict those of other acquisition studies that found that the acquisition of codas precedes that of complex

onsets? And secondly, how can we reconcile our findings with the existence of an implicational universal regarding codas and complex onsets in adult language typology?

The response to the first question is no. The question is a matter of terminological confusion surrounding the term ‘coda’. The studies that found earlier acquisition of codas mentioned in section 6.1 (Levelt & van de Vijver 2004; Levelt, Schiller, & Levelt 2000) use the term ‘coda’ without making a distinction between word medial codas and word final single consonants. In the corpus analysed by these researchers (namely, the Fikkert-Levelt corpus of child language (Fikkert 1994; Levelt 1994; MacWhinney 2000)) word final single consonants are acquired before branching onsets. However, the data show no such implication with respect to medial codas and complex onsets. The examples in 69 show that Jarmo could produce complex onsets at a time when he could not produce word medial codas (Fikkert 1994) (see also discussion in chapter 1, section 4.3).

69. a. Complex onsets

*kla: r* → *kla:*                      ‘ready’                      1;11,06

b. Medial codas

*'rarkəns* → *'kakəs*  
                     → *'fakəs*                      ‘pigs’                      2;0

Therefore, these studies do not make any claims about the acquisition of complex onsets as compared to medial codas, which is the issue in question here.

With respect to the existence of an implicational universal in adult language typology, the situation is not as clear. It is generally accepted that there exists an implicational universal regarding complex onsets and codas. However, there are a number of languages that are accepted as potential counterexamples to the universal, even by its supporters (Davis & Baertsch 2006). For example, Davis & Baertsch (2006) report that some Yanomami dialects in Brazil have a (C<sub>1</sub>)(C<sub>2</sub>)V syllable structure, with TR as the only cluster type allowed (Migliazza 1972). The examples in 70 show TR clusters in word initial and word medial position (from Milliken et al (2002)).

70. *prika* ‘pepper’

*prohe* ‘loose’

*tukri* ‘piranha’

The following example (Dixon & Aikhenvald 1999) shows a complex verb and illustrates the otherwise CV structure of Yanomama with the exception of a single TR (here *pr*) cluster.

71. *fama e-ki-pata-rə-hore-pi-pra-ma-re-həri-no-ve-i*

tapir OBL-DL-AUGMENTATIVE-TOPIC-rush.off-DL-DISCONTINUOUS-

CAUS-TELIC-DIRECTIONAL-ACCOMPLISHED-AFFIRMATIVE-

EYEWITNESS

‘making two huge tapirs rush away’

Notably, this is not the only language that has been reported as having complex onsets while lacking codas. Besides Yanomama, Davis & Baertsch (2006) also mention Piro, Mazateco and Vata. In the same vein, Blevins (1995) also reports Pirahã and Arabela. However, the status of these languages as counterexamples has been the subject of much debate (see Kaye (1985) on Vata, Lin (1997) on Piro, Steriade (1994) on Mazateco). Although I do not intend to settle the debate here, for the purposes of our investigation suffice it to say that the existence of the implicational universal under discussion is yet to be confirmed. Therefore, it may turn out that the various theoretical stipulations that have been made in relation to this issue are unnecessary.

## 7 Conclusion

In this chapter, I discussed the acquisition of sT clusters. In a first attempt to examine the acquisition of these clusters in CVCV theory, I proposed an auxiliary hypothesis to the model. I argued that, in contrast to other phonological models, the CVCV model makes correct predictions with regard to the acquisition of sT clusters, when compared to other cluster types. The main findings are summarised below (the right-hand column refers to the section in which the findings were reported).

## 72. Findings Section

#sT > #TT 2

#sT = #TR 3

#TR > #TT 3

#sT = -sT 4

-sT = -TR 5

(sT, -TT, -RT) = -TR 6

> better performance

= similar performance

## CHAPTER 5. CLUSTER DISSIMILATION

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### 1 Introduction

In this chapter, I discuss the acquisition of clusters of voiceless stops (*pt/kt*) and voiceless fricatives (*fθ/xθ*) in Greek. These clusters are closely linked to sociolinguistic questions, since until recently they were not allowed in popular Greek, but only in a high superimposed variety. Popular Greek only allowed dissimilar (fricative-stop) clusters instead.

Building on the analysis of Seigneur-Froli (2003, 2004, 2006) in CVCV theory, I propose a complexity parameter that can capture the historical evolution of these clusters and makes predictions regarding their acquisition. The chapter proceeds as follows. Section 2 presents the evolution of the clusters and the proposed analysis, including a complexity parameter. The ensuing predictions are tested with an acquisition experiment reported in section 3. Section 4 is an initial investigation of possible triggers for the diachronic change in the setting of the proposed parameter. A short conclusion follows.

### 2 The historical and theoretical background

#### 2.1 Greek Diglossia

The linguistic situation in Greece for centuries has been that of Diglossia (Ferguson 1959). This is a situation in which two linguistic varieties coexist within a country-state: one of them is a superimposed variety, usually the vehicle of literature<sup>1</sup>. It is

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<sup>1</sup> The situation may extend beyond the unit of a country-state: the same language-variety may be superimposed to a number of different countries (for example in the case of Arabic).

learned through formal education and is used for formal written and spoken purposes.

Greek throughout history has had two varieties, a low one, used as everyday language, and a high one, used in literature and often supported by authority (Horrocks 1997). In 1830, when Greece became an independent state, the language that became the official language of the new nation was Katharevusa, a “purified demotic”, with some elements of the popular language and resuscitated forms and elements of ancient Greek. Katharevusa was a constructed language that nobody spoke consistently (Browning 1983). It was used in literature, education and for official purposes, and became more and more remote from the comprehension of the average Greek.

This situation continued until 1974, when Demotic became the official language. Since 1974 the language spoken in Greece, has been a mixture of the popular language and Katharevusa in many respects (Mackridge 1985). Moreover, in some cases (structures and words), two possibilities have co-existed, one of Demotic origin and one of Katharevusa origin, which serves as a social marker for the speaker (Kazazis 1992). The choice of features of one over the other indicates stylistic preferences and also marks the linguistic register and the social class and background of the speaker (Trudgill 1983).

## 2.2 The clusters

The fricative-fricative and stop-stop clusters constitute an example of such language mixture. In modern Greek, there are fricative-fricative clusters (*fθ*, *xθ* e.g. *ixθiopol'io* ‘fishmonger’s’), stop clusters (*pt*, *kt* e.g. *per'iptero* ‘kiosk’) and fricative-stop clusters (*ft*, *xt*, see chapter 3, section 2). However, some words have two forms: one that contains a fricative-stop sequence, and one that contains a corresponding fricative-fricative or stop-stop sequence<sup>2</sup> (1). In these cases, the speaker’s choice is dependent on sociolinguistic factors, and the fricative-fricative/stop-stop sequences have been argued to be linked to higher register (Tserdanelis 2001).

### 1. a. Stop-stop

*kt'ena* - *xt'ena* ‘comb’

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<sup>2</sup> For stop-fricative clusters see footnote 7.



*ept'a - eft'a* 'seven'

*okt'o - oxt'o* 'eight'

b. Fricative-fricative

*xθes - xtes* 'yesterday'

*fθin'os - ftin'os* 'cheap'

*an'ixθika - an'ixtika* 'open'PASS. PAST.1<sup>ST</sup> SG

The dissimilar (fricative-stop) forms originate in Demotic, while the similar (fricative-fricative and stop-stop) forms come from Katharevusa. The use of Katharevusa in education and later in mass media was the cause of the introduction of the similar clusters into standard Greek.

The clusters of Demotic origin have been analysed as the output of manner dissimilation, which was part of a series of changes that led from ancient to modern Greek (Browning (1983), Horrocks (1997)). These changes involved:

2. a. spirantisation of aspirated and voiced stops
- b. progressive manner dissimilation of voiceless fricatives (hardening)
- c. regressive manner dissimilation of voiceless stops (spirantisation)

Ancient Greek contained three series of stops: aspirated stops ( $p^h$ ,  $t^h$ ,  $k^h$ ), voiced stops ( $b, d, g$ ) and voiceless stops ( $p, t, k$ ). Process 2a, spirantisation, was context free and turned the former two series of stops into fricatives.

3. a. Aspirated stops

$k^h t^h es > xθes$  'yesterday'

$'ok^h t^h ee > 'oxθi$  'shore'

- b. Voiced stops

$'ogdoos > 'oyðoos$  'eighth'

Processes 2b and 2c, dissimilation, affected clusters of the (new) series of voiceless fricatives (4a), and clusters of voiceless stops (4b) respectively.

#### 4. a. Fricatives

*xθes* > *xtes* ‘yesterday’

*fθ'ano* > *ft'ano* ‘arrive’ 1<sup>ST</sup> SG

*'oxθi* > *'oxti* ‘shore’

#### b. Stops

*ept'a* > *eft'a* ‘seven’

*'ektos* > *'extos* ‘sixth’

According to this view, these historical rules resulted in most Greek dialects having fricative-stop clusters (Joseph & Philippaki-Warbuton 1987; Newton 1972). Then the older forms (similar clusters) were re-introduced by Katharevusa (Malikouti-Drachman 1987).

There is disagreement among researchers whether dissimilation rules are active synchronically (as optional rules) (Pagoni 1993) or not (Malikouti-Drachman 1987). Seigneur-Froli (2006) argues that the rule is not synchronic, on the basis of the existence of forms that do not exhibit variation (e.g. *'apteros* ‘wingless’ \**'afteros*) and of minimal pairs (*fθ'ino* ‘decline’, *ft'ino* ‘spit’). Such forms constitute evidence that the phonological system of (modern) Greek allows both cluster types lexically.

Seigneur-Froli (2003, 2004, 2006) proposes an analysis of dissimilation as positional lenition in CVCV theory. In CVCV theory, segmental strength is dependent on the combined action of government and licensing (Ségéral & Scheer 2001). Specifically, licensing strengthens the segmental expression of its target, while government weakens the segmental expression of its target<sup>3</sup>. A well-known

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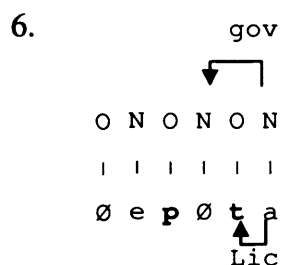
<sup>3</sup> This segmental function of government and licensing forces is of the same type as the role of these forces in the construction of syllable structure, as discussed in chapter 2. Precisely, government acts as a weakening/inhibiting force at the syllabic level, as well as at the segmental level. At the syllabic level, this results in the (alternating or empty) nucleus targeted by government being allowed to remain phonetically unexpressed (chapter 2, sections 2.3 and 7.2.1). In contrast, licensing acts as a strengthening force at the syllabic level, as well as at the segmental level. At the syllabic level, this results in the sonorant that is targeted by licensing being able to govern infrasegmentally the preceding obstruent (chapter 2, section 4.2).

phenomenon in romance languages is that a (word internal) postconsonantal position is strong, while a (word internal) preconsonantal position is relatively weaker. For instance, Latin postconsonantal *p* is preserved in French (*talpa* > *top* taupe ‘mole’), while preconsonantal *p* is not (*rupta* > *rut* route ‘road’). The CVCV analysis of this asymmetry is that the former (postconsonantal) position is strong because it is licensed (5a), while the latter (preconsonantal) position is weak because it is not licensed (5b).

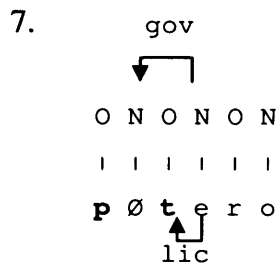
5.



Seigneur-Froli (2003, 2004, 2006) argues that cluster dissimilation in Greek is part of the same phenomenon. Word medial preconsonantal stops became fricatives (*ep<sup>h</sup>t<sup>h</sup>a* < *eft<sup>h</sup>a*) because they are in an unlicensed position (6). This contrasts with the licensed (strong) postconsonantal position in the same example, where the stop was preserved (*ep<sup>h</sup>t<sup>h</sup>a* < *eft<sup>h</sup>a*).

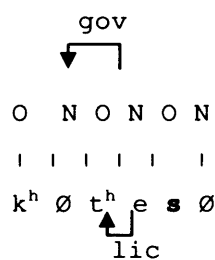


Word initial preconsonantal stops in Greek are also weak because they are in an unlicensed position (7), like their word medial counterparts. Word initial preconsonantal stops also became fricatives (*pter<sup>h</sup>o* < *fter<sup>h</sup>o*). The stops following them, being in a licensed (strong) position, were preserved (*pter<sup>h</sup>o* < *fter<sup>h</sup>o*) like word medial postconsonantal stops.

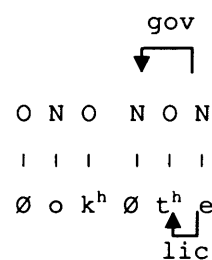


As far as the evolution of clusters of aspirated stops is concerned, Seigneur-Froli (2003) argues that their development into fricative-stop clusters was not preceded by the alleged intermediate step of fricative-fricative clusters (cf. 3). Using evidence of comparative and orthographic nature, she challenges the interpretation of Egyptian and Latin transcriptions of Greek and argues against the existence of a fricative-fricative stage in the development of these clusters;  $xt$  originates in  $k^ht^h$ , without an intermediate step  $x\theta^4$ . The analysis she proposes for clusters of aspirated stops is similar to her analysis of clusters of (unaspirated) stops mentioned above: the first (aspirated) stop, being in an unlicensed, weak position, lost stopness ( $k^ht^hes < xtes$  'yesterday'), in contrast to the second stop, which, being in a strong, licensed position, retained stopness ( $k^ht^hes < xtes$  'yesterday'). The analysis holds for both word initial (8a) and word medial (8b) clusters.

8. a. Word initial position



b. Word medial position



How is loss of stopness represented in CVCV theory? Following Government Phonology research on monovalent elements (see e.g. Harris (1990)), stopness is represented by a stop element, which differentiates stops from fricatives (9).

<sup>4</sup> Notice that, according to this view, Katharevusa introduced *novel* clusters ( $f\theta$ ,  $x\theta$ ) to the language, instead of re-introducing older forms.

9.	<i>p</i>	<i>f</i>
	x	x
	l	l
	h	h
	l	l
	U	U
	l	
	?	

The elemental make-up of the sounds in 9 is taken from Pagoni's (1993) analysis of Greek consonants. It involves the place element U, along with the noise element h and the stop/occlusion element. Following Pagoni (1993), I assume that in Greek a voiceless stop consists of a stop element, a noise and a place element, while the corresponding fricative lacks the stop element. However, the exact representation of these consonants is not crucial for our discussion. Despite the fact that there are numerous proposals for the internal composition of consonants in terms of elements (see chapter 1, footnote 3), most Government Phonology and CVCV analyses would agree on the statement that a fricative is the lenited version of the corresponding stop, via the loss of some kind of stop element<sup>5</sup>.

### 2.3 The proposal: a complexity parameter

CVCV theory provides us with the tools to determine which positions are strong or weak, and consequently where we should expect to find lenition or fortition diachronically, and where it would be impossible for them to happen. However, the question of what changes in the speaker's grammar when such processes occur is left open.

Following Lightfoot (1991, 1999) in connecting language change to changes in parameter settings (see discussion in section 4), I argue for the existence of a parameter that was responsible for the historical change. The parameter is based on

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<sup>5</sup> The statement refers primarily to the historical development of sound change. See chapter 1, footnote 5.

the distinction between a preconsonantal and a postconsonantal position: recall that in CVCV theory the former position is unlicensed while the latter is licensed. The parameter has the following two settings:

#### 10. Complexity Parameter

##### Setting a.

If A is a licensed position and B an adjacent unlicensed one, and  $\alpha$  is the number of elements in A and  $\beta$  the number of elements in B, then  $\beta$  must be smaller than  $\alpha$ <sup>6</sup>.

##### Setting b.

If A is a licensed position and B an adjacent unlicensed one, and  $\alpha$  is the number of elements in A and  $\beta$  the number of elements in B, then  $\beta$  must be smaller than or the same as  $\alpha$ .

And more formally:

#### 11. Setting a. $\beta < \alpha$

##### Setting b. $\beta \leq \alpha$

Before proceeding to a discussion of the parameter, let us briefly see how the parameter relates to the clusters we are examining. In a word like *eft<sup>l</sup>a*, for instance, *f* is unlicensed and *t* is licensed. *f* contains a smaller number of elements than *t* (see below). As a result, the cluster is allowed under both parameter settings. In contrast, in the word *ept<sup>l</sup>a* the unlicensed and licensed positions, occupied by *p* and *t* respectively, have the same number of elements. Therefore, the cluster is allowed under the setting (b) only.

The proposed parameter follows the spirit of the Complexity Condition (Harris (1990), see chapter 1, section 4.1). From the early days of Government phonology it was argued that some positions are disadvantaged compared to others, in terms of elemental content (see also Kaye et al (1990)). The number of elements

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<sup>6</sup> Note that the parameter does not need to involve counting as it can be structured using a stack system of the type used in some parsing models (e.g. Miller (1994), Shieber (1983)).

that these positions are allowed to contain cannot be higher than that allowed in some other, more privileged positions. In the same spirit, the Licensing Inheritance theory was developed (Harris 1997) according to which a position inherits licensing potential from its licensor. According to this system, licensing determines syllable structure, and part of its effects is that the lower down the licensing hierarchy a position is, the fewer elements it is allowed to contain. Different versions of the Complexity Condition or Licensing Inheritance have been used in Backley (1995), Nasukawa (1995, 2005), Pagoni (1993), Rice (1992), Takahashi (1993, 2004), amongst others.

The parameter in 10 is a direct translation of the Complexity Condition into CVCV theory, with the addition of binarity: a language may allow an unlicensed position to have as many elements 'as the licensed one'<sup>7</sup>, or enforce a tighter restriction, demanding that it have fewer elements<sup>8</sup>.

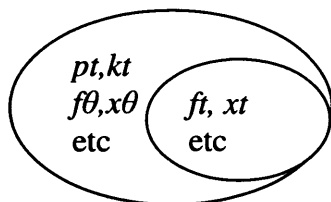
The default setting for the parameter would need to be setting (a). This follows from learnability requirements. Specifically, the possible forms allowed under setting (a) are a proper subset of the possible forms allowed under setting (b). This is because forms with a smaller number of elements in the unlicensed position would satisfy both settings, while forms with the same number of elements in licensed and unlicensed positions can only exist under setting (b).

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<sup>7</sup> A more complete examination of the Greek consonantal system might reveal that the marked setting of the parameter has to be further relaxed, allowing a higher number of elements in the unlicensed position. This is suggested by the existence of stop-fricative sequences: *ts*, *ks*, *ps*. However, several analyses assume a contour segment structure, for stop-fricative sequences, at least for *ts* (see Pagoni (1993) and references therein). Note, also that all of these sequences have *s* as their second member; sequences like *\*pθ*, *\*kf* are not allowed in Greek. If the parameter is relaxed, so that any segment type is allowed in either position, clusters such as *pθ* and *kf* would only be accidental gaps. I leave this question for further research.

<sup>8</sup> Because structure and strength in CVCV theory depend on a *combination* of government and licensing, a complete parametric system will include both of these forces. However, the proposed parameter is sufficient for our purposes, since the two positions we are examining are only differentiated by the absence versus presence of licensing. Moreover, the parameter could be more fine-grained, to include even tighter restrictions on the number of elements, and should be studied in conjunction with licensing constraints (Charette & Göksel 1996; Kula 2005), which impose restrictions on the possible combinations of elements within a segment. These are issues for further research.

## 12. A subset relation



small oval: setting (a)

large oval: setting (b)

Let us now see how the complexity parameter can describe the diachronic evolution of the Greek clusters. As we saw in section 2.2, Ancient Greek contained clusters of voiceless stops such as *pt*. These clusters would have the same number of elements in the unlicensed and the licensed position.

13. <i>p</i>	<i>t</i>
x	x
h	h
U	R
?	?

In the representation above, *p* (in the preconsonantal unlicensed position) contains three elements, right next to a licensed position, occupied by *t*, which also contains three elements. This indicates that the complexity parameter was set to the marked setting (10b), allowing for an unlicensed position to have the same number of elements as the licensed one.

Compare this with the forms that arose with the dissimilation, as that was described earlier.



14. <i>f</i>	<i>t</i>
x	x
l	l
h	h
l	l
U	R
	l
	?

With the loss of stopness, the new forms had fewer elements in the unlicensed position than in the licensed one. The forms with the same number of elements were no longer generated by the grammar. This corresponds to a move from the marked setting (10b) to the unmarked setting (10a).

Moreover, clusters of aspirated stops followed a similar development, in a cascade effect manner. Rule 2a involves spirantisation of voiceless aspirated stops. This is attested in the case of singletons.

15. <i>otʰoni</i>	>	<i>oθʰoni</i>
<i>tʰelo</i>	>	<i>θʰelo</i>

However, in the case of clusters of aspirated stops, spirantisation would create clusters of fricatives, a sequence that would be illegal under the new parameter setting. A cluster like *fθ*, for example, would contain the same number of elements in the two positions, licensed and unlicensed one, contrary to the requirements of the parameter.

16. <i>f</i>	<i>θ</i>
x	x
l	l
h	h
l	l
U	R

Since the resulting cluster would be illegal, the end result would have to be modified in order to conform to the new parameter setting, having a greater number of elements in the licensed position. This meant that instead of  $f\theta$  the cluster arising from  $p^ht^h$  was  $ft$ .

$$17. p^ht^h > (*f\theta) > ft$$

The evolution proposed here is in line with the evidence presented against the traditionally assumed existence of the intermediate step  $f\theta$  (Seigneur-Froli 2003)<sup>9</sup>.

Finally, the evolution of voiced stops at first glance appears to violate the new parameter setting. Voiced stops also underwent spirantisation (2a). The resulting clusters of voiced fricatives (3b) would appear to violate the parameter setting by having the same number of elements in the two positions (just like clusters of voiceless stops or fricatives would, as we saw above). However, this is not the case. The difference between voiceless and voiced consonants in Greek is the voice element L (Pagoni 1993)<sup>10</sup>. In clusters of voiced fricatives, this element originates in the licensed position and spreads to the unlicensed one (see representation of  $v\delta$  below).

18. $v$	$\delta$
x	x
l	l
h	h
l	l
U	R
l	l
<<	L

---

<sup>9</sup> Note that the complexity parameter would also be consistent with a scenario whereby an intermediate step containing clusters of voiceless fricatives was attested. If spirantisation had taken place before the parameter change, then we should be able to find evidence for an intermediate step  $f\theta$ .

<sup>10</sup> In the case of voiced stops, Pagoni proposes an analysis that involves an interaction between a plain (voiceless) stop and a preceding nasal segment.

In the above representation, the first of the two fricatives receives its voicing from the second one. This representation is supported by the fact that sequences of a voiceless and a voiced fricative are not allowed, thus indicating that the two fricatives share their voice element. The representation is also consistent with analyses of clusters in languages that allow only geminates and/or homorganic nasal-consonant clusters (see Harris (1990)). The unlicensed position in such languages is analysed as only having one element (in the case of nasal-consonant clusters) or none (in the case of geminates), the source of the rest of the elements being the licensed position.

The implication of the above is that clusters of voiced fricatives in Greek respect the unmarked setting of the complexity parameter, which requires a smaller number of elements in the unlicensed position. This explains what the rules in 2b-2c describe, but fail to explain, namely the lack of dissimilation in clusters of voiced fricatives.

The claim as to the existence of the complexity parameter can be tested on typological data. The subset relation expressed in 12, regarding fricative-stop clusters and clusters of two fricatives or two stops, constitutes a claim for the relative markedness of these cluster types. Precisely, it is claimed that fricative-fricative and stop-stop clusters are more marked than fricative-stop clusters. The relevant prediction for language typology is therefore that there exists an implicational universal, whereby the presence of fricative-fricative or stop-stop clusters in a language implies the presence of fricative-stop clusters.

Although I do not intend to conduct a full investigation of this universal here, the results of an initial investigation are encouraging. Greenberg (1978) examined word initial clusters in 104 languages and found strong tendencies in the direction of the predicted universal. Specifically, according to Greenberg, the existence of fricative-fricative clusters word initially implies the existence of fricative-stop clusters in the same position, with one exception (Karen), and the existence of stop-stop clusters word initially implies the existence of fricative-stop clusters in the same position, with two exceptions (Huichol and Takelma). More recent analysis of the three apparently misbehaving languages indicates that these do not in fact constitute exceptions (Morelli 1999). Morelli (1999) proceeds to an in depth analysis of the potential counterexamples as she is arguing for the typological implication predicted

here. Precisely, she claims that fricative-stop clusters are the most unmarked type of obstruent-obstruent clusters (more unmarked than fricative-fricative and stop-stop clusters) and she develops an Optimality Theoretic model to account for adult language typology.

As the focus of this thesis is first language acquisition, I will test the proposal against developmental data. According to the complexity parameter, fricative-stop clusters are allowed under both the unmarked as well as the marked setting of the parameter. In contrast, fricative-fricative and stop-stop clusters are allowed under the marked setting of the parameter only. As a result, we predict that in a language that allows both of these cluster types, such as (modern) Greek, children will acquire the unmarked (fricative-stop) clusters first.

However, before this prediction can be tested, some clarifications are in order. Although (modern) Greek allows both fricative-fricative/stop-stop and fricative-stop clusters, their distribution is partly influenced by sociolinguistic factors. While in some cases speakers have clear intuitions as to which cluster is involved in the pronunciation of a given word, some words allow either cluster, the fricative-fricative/stop-stop option being possibly associated with a higher register Tserdanelis (2001). As a result of this situation, we are faced with a potentially confounding variable. If – upon testing children on their performance in fricative-fricative/stop-stop and fricative-stop clusters – we were to find that they performed better in fricative-stop contexts, it would remain unclear whether this is due to the complexity parameter being set as unmarked or whether the children were simply responding to the sociolinguistic situation, thus producing variants compatible with a lower register. However, it turns out that these two potentially determining factors can be teased apart once we approach the matter from a different perspective.

Assuming that child language is sociolinguistically consistent across ages, the parameter I propose makes a specific prediction with regard to children's acquisitional path. Although, due to the sociolinguistic component, it may be the case that all children perform dissimilation of fricative-fricative/stop-stop clusters some of the time, the current proposal also expects that younger children will produce a *higher ratio* of dissimilar to similar clusters when compared to older children, as their grammar has not yet reached the marked setting for the complexity parameter. If, on the other hand, the only factor involved in the children's production of fricative-fricative/stop-stop and fricative-stop clusters is of a sociolinguistic

nature, we expect that there should be no difference between the younger and the older children. Note that by comparing the *ratio* of the relevant clusters, we control for the fact that children's production tends to improve as children grow older (younger children tend to produce singletons instead of clusters).

### 3 The experiment

#### 3.1 Goal

The purpose of this experiment is to test Greek children's production of similar (fricative-fricative and stop-stop) clusters. The goal of the experiment is twofold.

Firstly, as these clusters are TT clusters, the experiment tests the hypothesis that their acquisition in word medial position precedes acquisition in word initial position (see chapter 3, section 2). The experimental hypothesis is that children's performance in word medial position will be better than their performance in word medial condition. The null hypothesis is that there will be no difference in performance between the two positions.

- |           |           |                       |
|-----------|-----------|-----------------------|
| 19. $H_1$ | -TT > #TT | > better performance  |
| $H_0$     | -TT = #TT | = similar performance |

Secondly, the experiment tests the complexity parameter proposed in the previous section. Specifically, it is expected that the ratio of dissimilar to similar clusters will decrease with age. The experimental hypothesis is that children will produce a *higher ratio* of dissimilar to similar clusters when compared to older children. The null hypothesis is that there will be no difference between age groups.

- |           |                                   |                                   |
|-----------|-----------------------------------|-----------------------------------|
| 20. $H_1$ | younger children > older children | > higher ratio dissimilar/similar |
| $H_0$     | younger children = older children | = same ratio dissimilar/similar   |

#### 3.2 Methods and materials

Subjects, methodology and procedure were the same as in the previous experiments (see chapter 3, sections 3.3.1, 3.3.2 and 3.3.4 respectively). A non-word repetition task was used to test the consonant cluster production of fifty-nine monolingual

Greek children. Children were asked to repeat words that contained the target cluster and their responses were recorded and transcribed.

The experiment consisted of two conditions: the first condition involved words with clusters of two voiceless fricatives or two voiceless stops in initial position, and the second condition contained words with the same clusters in medial position. Specifically, the following combinations of consonants were tested:

21. *fθ, xθ, kt, pt*

The non-words were designed following the same principles as in the previous experiments (see chapter 3, section 3.3.3), forming feminine or neuter nouns. All words were bisyllabic, with a voiceless stop as an onset for the non target syllable: *p, t* or *k*. The stimuli used in the word initial condition are listed in 22.

22. *fθ<sup>h</sup>oki, xθ<sup>h</sup>api, kt<sup>h</sup>ito, pt<sup>h</sup>ika*

The stimuli used in the word medial condition were formed by reversing the syllable order. The stimuli were the following:

23. *kifθ<sup>h</sup>o, pixθ<sup>h</sup>a, tokt<sup>h</sup>i, kap<sup>h</sup>t<sup>h</sup>i*

For uniformity, the target cluster always preceded the stressed vowel.

Moreover, because these clusters are linked to sociolinguistic issues, and in order to control for possible sociolinguistic factors in children's production, children of different social backgrounds are tested. Specifically, children were tested in nurseries of two types, corresponding to two separate social classes: the first type consists of three state nurseries (including a Worker's Guild nursery) in working class areas, while the second nursery type consists of a single private nursery, in an area of higher socio-economic profile.

### 3.3 Results

#### 3.3.1 General results

Table 1 shows the categories used for coding the responses, with some examples. A short explanation of the code names and more examples follow.

Code	Stimulus	Response
Correct	<i>fθ'oki</i>	<i>fθ'oki</i>
Dissim	<i>xθ'api</i>	<i>xɾ'api</i>
Drop 1 <sup>st</sup>	<i>fθ'oki</i>	<i>θ'oki</i>
Drop 2nd	<i>pɾ'ika</i>	<i>p'ika</i>
Other single	<i>fθ'oki</i>	<i>p'oki</i>
Other	<i>fθ'oki</i>	<i>fl'oki</i>

Table 1. Categories used in coding with examples of corresponding responses

“Correct” indicates an adult-like cluster. For instance:

24. *fθ'oki* → *fθ'oki* (Emanouela 4;11,21)

*kt'ito* → *kt'ito* (Argiroula 3;04,01)

*pɾ'ika* → *pɾ'ika* (Vasiliki 3;10,15)

*xθ'api* → *xθ'api* (Eleni 3;06,16)

I coded as “Dissim” clusters of which the first member is a fricative and the second a stop that are the result of frication of the first member of the cluster in stop-stop stimuli (25a) and stopping of the second member in fricative-fricative stimuli (25b).

#### 25. a. Fricative-fricative

*fθ'ok i* → *ft'oki* (Dimitra 3;00,03)

*xθ'api* → *xɾ'api* (Zoi 4;02,17)

*fθ'oki* → *ft'oki* (Dimitra 3;04,12)

#### b. Stop-stop

*kt'ito* → *xɾ'ito* (Kostantina 3;11,11)

*pt'ika* → *ft'ika* (Mirto 3;00)

*kt'ito* → *xt'iko* (Manos 3;04,04)

*pt'ika* → *ft'ika* (Kostantina 3;11)

‘Drops 1<sup>st</sup>’ indicates that the child drops the first of the two consonants. For example:

26. *fθ'oki* → *θ'oki* (Epistimi 2;03,08)

*kt'ito* → *t'ito* (Andreas 4;03,16)

*pt'ika* → *t'ika* (Pantelis 3;01,29)

*xθ'api* → *θ'api* (Antonis 3;06,04)

In ‘Drops 2<sup>nd</sup>’ the child drops the second consonant of the cluster.

27. *fθ'oki* → *f'oki* (Mario 3;03,01)

*pt'ika* → *p'ika* (Despina 3;06,29)

*xθ'api* → *x'apti* (Argiroula 3;04,01)

*kt'ito* → *k'ito* (Manouela 2;11,19)

‘Other single’ responses contain a single consonant that is neither of the two consonants of the stimulus cluster.

28. *fθ'oki* → *p'oki* (Manouela 2;11,19)

*xθ'api* → *f'api* (Emanouil 2;10,20)

“Other” indicates any other response. This includes a change of one of the consonants or a different cluster (change of both consonants).

29. *fθ'oki* → *fl'oki* (Nikos 4;03,17)

*fθ'oki* → *xr'oki* (Aglaia 3;03)



Following the coding mentioned above, the results for the word initial condition are given in Figure 1. The detailed results, including raw numbers, are given in the appendix.

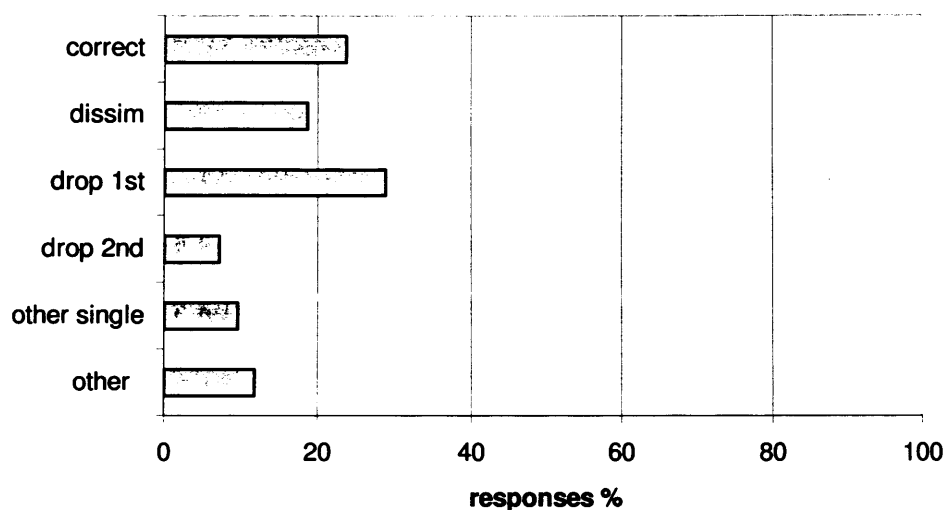


Fig. 1. Word initial TT clusters (n=236), percentage of responses by category for all children combined

Dropping of the first consonant was the most common response, given more frequently than correct responses. The percentage of dissimilation was about as high, while the rest of the responses (including dropping of the second consonant) were given infrequently.

In 30-35 I list some examples of children's responses in the word medial condition.

### 30. Correct

*kapt'i* → *kapt'i* (Giota 3;04,16)

*kifθ'o* → *kifθ'o* (Eleni 3;06,16)

*pixθ'a* → *pixθ'a* (Antonia 2;11,20)

*tokt'i* → *tokt'i* (Stavros 3;11,24)

### 31. Dissim

*pixθ'a* → *pixt'a* (Maro 3;09)

*kifθ'o* → *kift'o* (Manolios 4;00)

*tokt'i* → *toxt'i* (Stamatis 3;08)

*kapt'i* → *kapt'i* (Manthos 3;00)

32. Drop 1<sup>st</sup>

*kapt'i* → *kat'i* (Vagelio 2;10,07)

*kifθ'o* → *kiθ'o* (Mirto 3;00)

33. Drop 2<sup>nd</sup>

*kapt'i* → *kap'i* (Emanouil 2;10,20)

*kifθ'o* → *kif'o* (Manolis 3;10,01)

*pixθ'a* → *pix'a* (Nikolas 2;10,29)

34. Other single

*pixθ'a* → *pif'a* (Marios 3;01)

*tokt'i* → *top'i* (Agelos 3;04,12)

35. Other

*pixθ'a* → *piθx'a* (Vaso 3;10,25)

*tokt'i* → *kort'i* (Nikolas 2;10,29)

*kapt'i* → *kaput'i* (Vasiliki 3;10)

Figure 2 contains the results for the word medial condition, according to these coding conventions. The detailed results, including raw numbers, are given in the appendix.

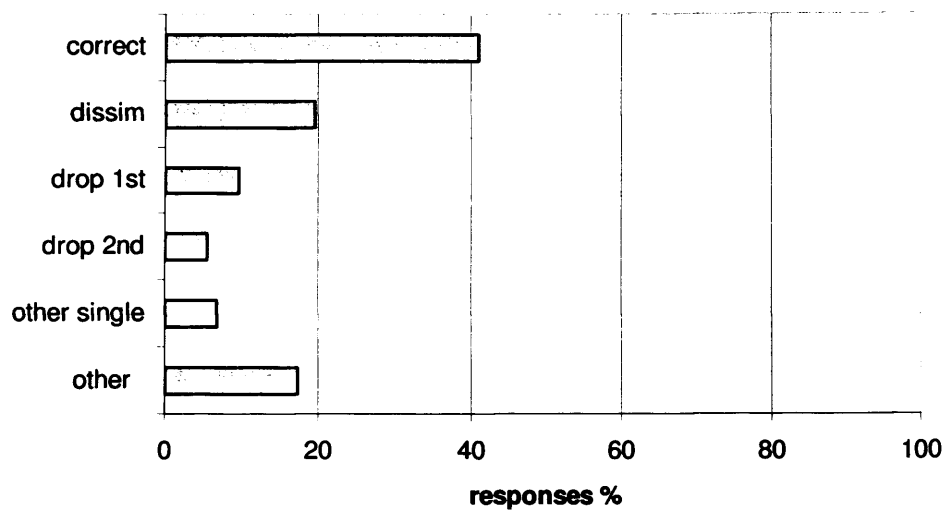


Fig. 2. Word medial TT clusters (n=236), percentage of responses by category for all children combined

In the word medial condition, correct responses were given around 40 percent of the time. The most common non-target response was dissimilation, while the first and second consonants were dropped far less often.

### 3.3.2 #TT versus -TT

When comparing performance in the two positions, a difference emerges. Children gave correct responses in the word medial condition about twice as often as in the word initial condition (Figure 3).

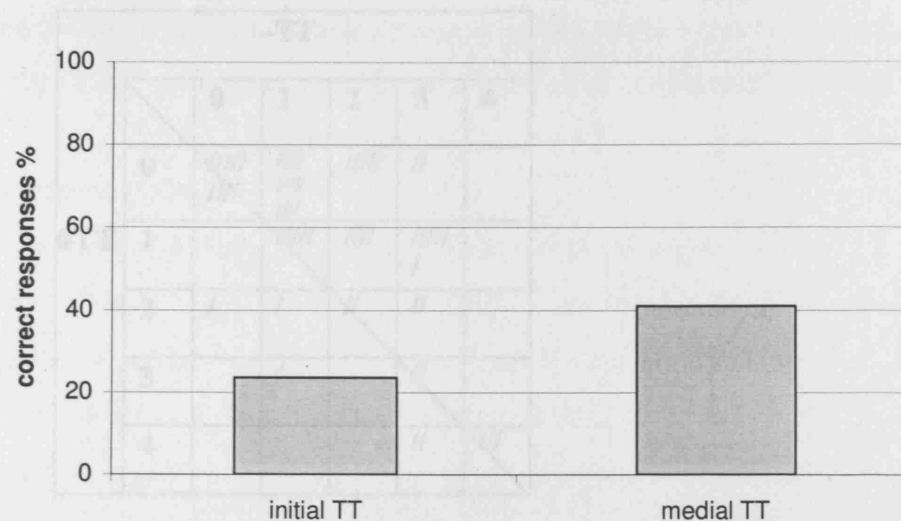


Table 3: Correct responses for initial and medial TT by each child

Fig. 3. Percentage of correct responses for word initial versus word medial TT clusters for all children combined

A chi-square test was carried out to discover whether there was a significant relationship between position and performance (number of correct responses). The  $\chi^2$  value of 16.257 had an associated probability value of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. It can therefore be concluded that there is a significant association between position and performance. As seen in figure 3, children's performance was better in word medial position.

Furthermore, I present below a table containing the number of correct responses for each child in word initial and word medial position.

A visual examination of the table shows that most children performed better at medial TT than at initial TT. The top right sector is populated more than the bottom left one. Several children performed better at -TT than at +TT, while there were few children that performed better at +TT than at -TT. Some examples of individual children's performance are given below. Agnes' performance (36a) was very poor

In the case of children that performed better at initial TT than at medial TT, the difference between the word initial condition and the word medial condition is consistently small (either one response difference (2-1, 4-3) or maximum two response difference (3-0, 3-1) (see table 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100).

		-TT					
#TT		0	1	2	3	4	
	0	//// ////	//// //// ////	////	//		
	1		////	///	//// /		
	2	/	/	//	//		
	3		/		//		
	4				//	///	

Table 2: Correct responses for initial and medial TT for each child

The vertical dimension represents the number of correct responses in the word initial condition (from zero to four), while the horizontal dimension corresponds to the number of correct responses in the word medial condition (again from zero to four). Each tally mark in the table cells represents a child (total 59 children). Children are divided into two groups, represented by the two sectors, divided by the diagonal: the top right sector contains children that performed better at medial TT, while the bottom left sector consists of children that performed better at initial TT. Children that fall on the diagonal performed the same in both conditions.

We expect that the top right sector will contain a greater number of children, an indication that each child performs better at medial TT than at initial TT. Children falling on the diagonal are also expected: these would be the ones that are acquiring the two structures simultaneously.

A visual examination of the table shows that most children performed better at medial TT than at initial TT. The top right sector is populated more than the bottom left one. Several children performed better at -TT than at #TT, while there were few children that performed better at #TT than at -TT<sup>11</sup>. Some examples of individual children's performance are given below. Agelos' performance (36a) was very poor

<sup>11</sup> In the cases of children that performed better at initial TT, the difference between the word initial condition and the word medial condition is consistently small: either one response difference (2-1, 4-3) or maximum two responses difference (2-0, 3-1) (see table 2).

in both conditions, while Emanouela (36b) performed at ceiling in both conditions. Finally, Nikos (36b) performed better in the word medial condition.

36. a. Agelos (3;04,12)

-TT: 0 out of 4 target

*tokt'i* → *top'i*

*pixθ'a* → *pixt'a*

*kifθ'o* → *kifl'o*

*kapt'i* → *kap'i*

#TT: 0 out of 4 target

*fθ'oki* → *ft'oki*

*xθ'api* → *θ'api*

*pt'ika* → *t'ika*

*kt'ito* → *xt'ito*

b. Emanouela (4;11,21)

- TT: 4 out of 4 target

*tokt'i* → *tokt'i*

*pixθ'a* → *pixθ'a*

*kifθ'o* → *kifθ'o*

*kapt'i* → *tapt'i*

#TT: 4 out of 4 target

*fθ'oki* → *fθ'oki*

*xθ'api* → *xθ'api*

*pt'ika* → *pt'ika*

*kt'ito* → *kt'ito*

c. Nikos (4;03,17)

- TT: 3 out of 4 target

*tokt'i* → *tokt'i*

*pixθ'a* → *pixθ'a*

*kapt'i* → *kapt'i*

*kifθ'o* → *kiθf'o*

#TT: 0 out of 4 target

*fθ'oki* → *fl'oki*

*xθ'api* → *θ'apti*

*pt'ika* → *tipt'ika*

*kt'ito* → *xt'ito*

In order to test the difference between the two sectors, a one-variable chi-square test was performed. The  $\chi^2$  value of 20.632, DF=1 had an associated probability value of  $p < 0.001$ . We can conclude that the difference between the two sectors is statistically significant.

Moreover, coding was repeated using the alternative criteria outlined in chapter 3, section 2.4.3. Specifically, our original coding protocol defined as correct only those responses that involve a consonant cluster that is identical to the target one. According to the alternative criteria any responses that involve a TT (obstruent-

obstruent) cluster are coded as correct, even if the cluster is not the target one. In this experiment, the difference between results according to the original criteria and those according to the alternative criteria is high. The reason is the considerable number of dissimilated responses, which, under the alternative criteria, are coded as correct. In addition to the dissimilated responses, there were further responses involving two obstruents, previously coded as incorrect and now coded as correct. Some such examples follow.

37. a. #TT clusters

*xθ<sup>l</sup>api* → *ft<sup>l</sup>apti* (Vasiliki 3;10,15)

*pt<sup>l</sup>ika* → *kt<sup>l</sup>ika* (Sofia 3;01)

b. -TT clusters

*pixθ<sup>l</sup>a* → *pifx<sup>l</sup>a* (Mixaela 4;06,04)

*tokt<sup>l</sup>i* → *opt<sup>l</sup>i* (Aglaia 3;03)

*kapt<sup>l</sup>i* → *kaxt<sup>l</sup>i* (Antonia 2;11,20)

Following the alternative criteria, responses were coded as correct versus non-correct (see appendix). In both conditions there was an increase of responses coded as correct of about 30 percent. Figure 4 contains the percentages of correct responses in the two conditions, according to the alternative criteria.

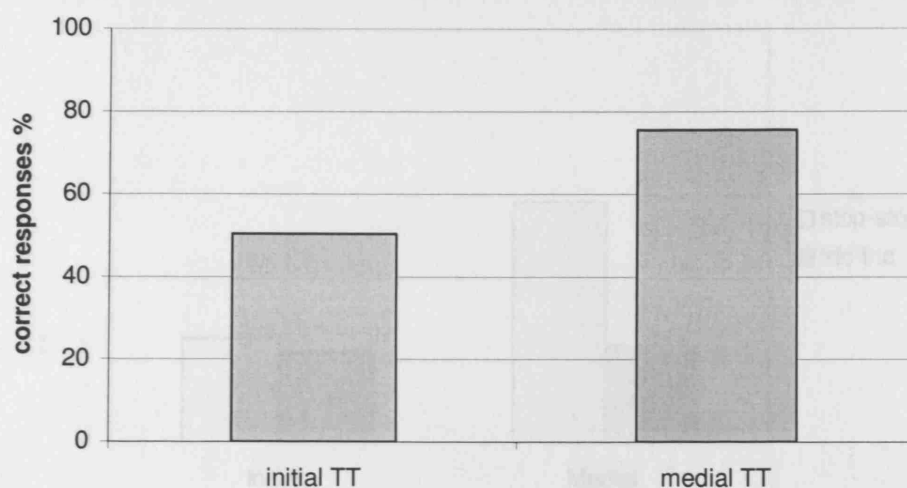


Fig. 4. Percentage of correct responses for word initial versus word medial TT clusters for all children combined, according to alternative criteria

The use of alternative criteria did not alter the relationship between the two conditions. As before, children's performance in the word initial condition was lower than in the word medial condition. A chi-square test had a  $\chi^2$  value of 32.770, with an associated probability value of  $p < 0.001$ ,  $DF=1$ , showing that such an association is extremely unlikely to have arisen as a result of sampling error. We can therefore conclude that there is a significant association between position and performance. Under the alternative coding criteria, too, children's performance was better in word medial position.

The stimuli can be divided into two sub-categories: stop-stop clusters (*pt, kt*) and fricative-fricative clusters (*fθ, xθ*). A comparison of children's performance in the two sub-categories showed no difference at the word initial condition ( $\chi^2 = 0.375$ ,  $DF=1$ ,  $p=0.541$ ), and better performance in the stop-stop sub-category at the word medial condition ( $\chi^2=29.423$ ,  $DF=1$ ,  $p < 0.001$ ). Moreover, when examining children's performance for each sub-category, we find that children performed significantly better word initially in the stop-stop sub-category ( $\chi^2=26.466$ ,  $DF=1$ ,  $p < 0.001$ ) but no difference was found between word initial and word medial positions in the fricative-fricative sub-category ( $\chi^2=0.096$ ,  $DF=1$ ,  $p=0.757$ ). Figure 5 shows the percentages of correct responses in the two sub-categories (for raw numbers see appendix).



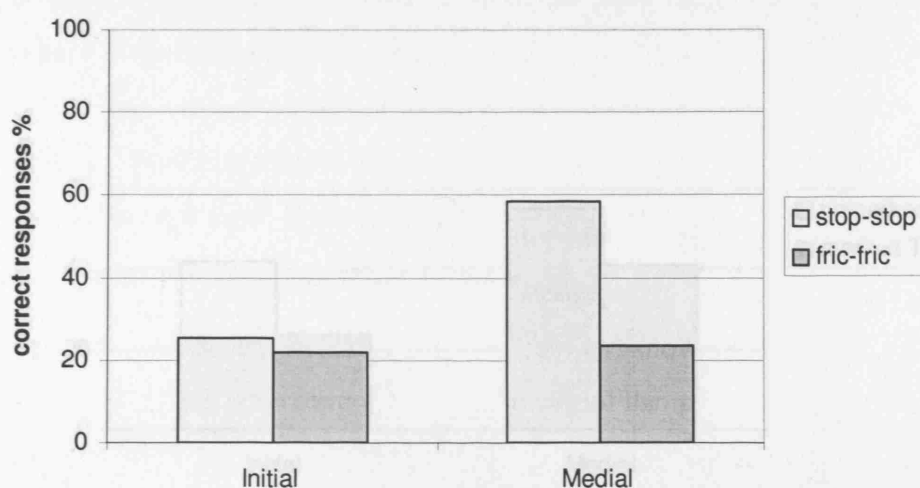


Fig. 5. Percentage of correct responses by cluster sub-category (stop-stop and fricative-fricative) in word initial and word medial position, for all children combined

### 3.3.3 Dissimilation

Finally, compare the results of this experiment with the results of the TT experiment in chapter 3, section 2. The TT experiment in chapter 3 examined Greek children's production of fricative-stop clusters and clusters of voiced fricatives. In terms of the complexity parameter, the experiment in chapter 3 examined the production of unmarked clusters, while this experiment examined children's production of marked clusters. A chi-square test testing the difference between the two experiments shows a significant difference in the percentage of target responses both in the word initial condition ( $\chi^2=19.606$ ,  $DF=1$ ,  $p<0.001$ ) and in the word medial condition ( $\chi^2=10.509$ ,  $DF=1$ ,  $p=0.001$ ). Figure 6 shows the percentages of correct responses in the two experiments. Children gave more correct responses in the unmarked TT experiment (chapter 3) than in the marked TT experiment (this chapter), in both conditions.



Fig. 7. Percentages of dissimilated responses at word initial and word medial position, for all children combined

Subsequently, coding was repeated using alternative criteria. Specifically, I coded as 'Dissim' all responses that involve a fricative-stop cluster, even if the place

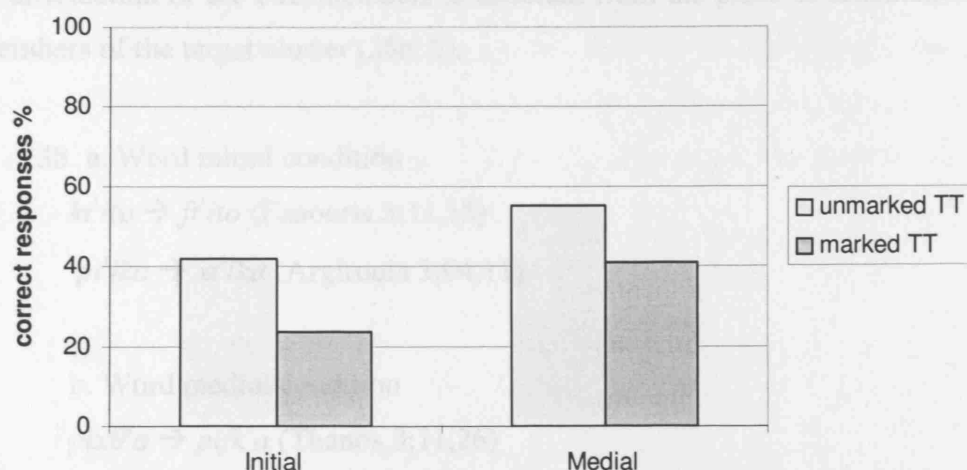


Fig. 6. Percentage of correct responses for unmarked TT versus marked TT clusters in word initial and word medial position, for all children combined

### 3.3.3 Dissimilation

Dissimilated responses were given around 20 percent of the time in both conditions (figure 7). No statistically significant difference was found between the two conditions ( $\chi^2=0.055$ ,  $DF=1$ ,  $p=0.815$ ).

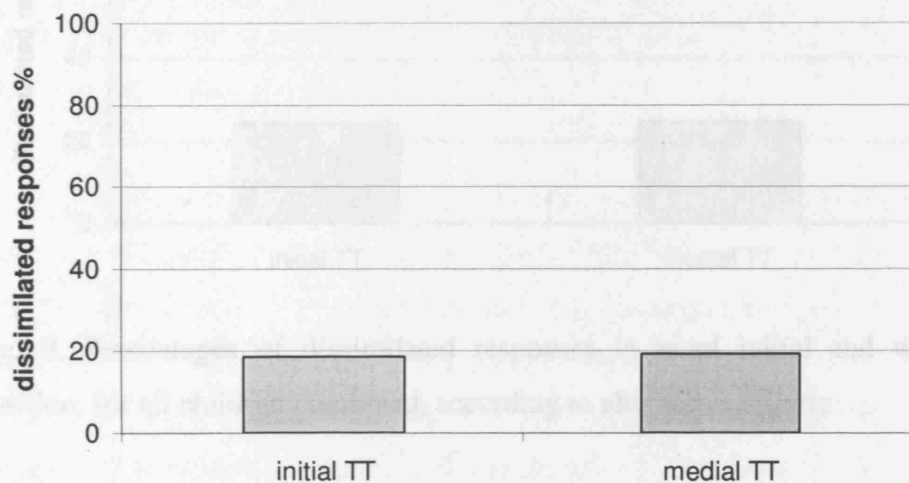


Fig. 7. Percentages of dissimilated responses in word initial and word medial position, for all children combined

Subsequently, coding was repeated using alternative criteria. Specifically, I coded as 'Dissim' all responses that involve a fricative-stop cluster, even if the place

of articulation of the two members is different from the place of articulation of the members of the target cluster (38a, b).

38. a. Word initial condition

*kt'ito* → *ft'ito* (Fanouris 3;11,15)

*pt'ika* → *xt'ika* (Argiroula 3;04,11)

b. Word medial condition

*pixθ'a* → *pifk'a* (Thanos 3;11,26)

*pixθ'a* → *pift'a* (Dimitra 3;00,03)

The percentages of dissimilated responses according to the alternative criteria are shown in figure 8 (for results see appendix).

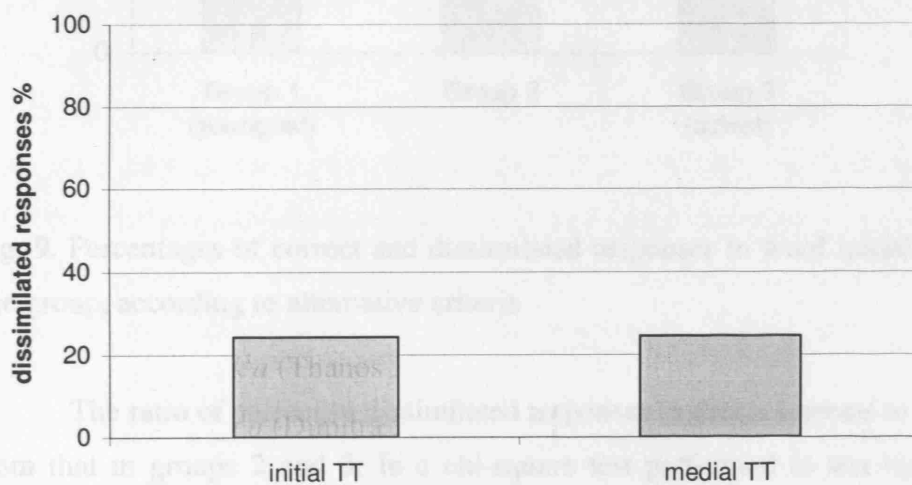


Fig. 8. Percentages of dissimilated responses in word initial and word medial position, for all children combined, according to alternative criteria

Application of the alternative criteria did not change the results regarding dissimilation in any significant way. Specifically, under the alternative criteria no statistically significant difference was found between the two conditions ( $\chi^2=0.865$ ,  $DF=1$ ,  $p=0.352$ ).

Moreover, a comparison of children's correct and dissimilated responses across age groups was made. Group 1 contains the youngest children (covering one-

year age difference starting with the youngest one 2;03-3;05 n=24), group 3 the oldest children (one-year age difference 4;00-5;00 n=17) and group 2 the children between the two other groups (3;06-3;11 n=18). Figure 9 compares children's correct and dissimilated responses in word initial position. For detailed results see appendix.

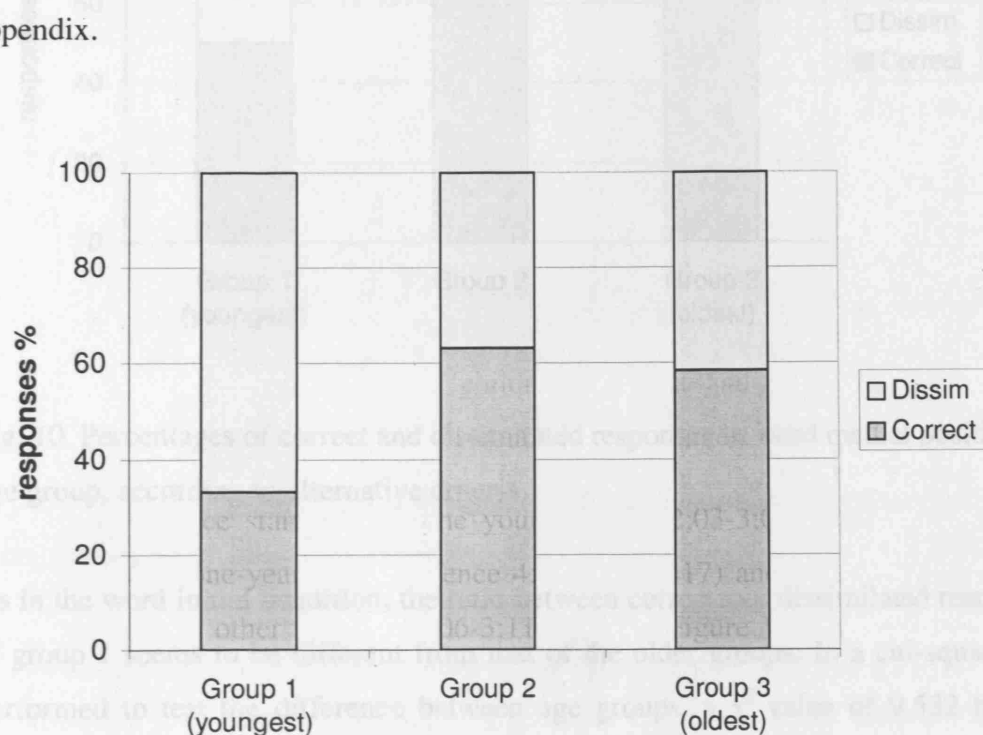


Fig. 9. Percentages of correct and dissimilated responses in word initial position by age group, according to alternative criteria

The ratio of correct to dissimilated responses in group 1 seems to be different from that in groups 2 and 3. In a chi-square test performed to test the difference between age groups, a  $\chi^2$  value of 8.034 had an associated probability value of  $p=0.018$ ,  $DF=2$ . Such an association is extremely unlikely to have arisen as a result of sampling error. We can thus conclude that the three age groups are not the same. Figure 9 shows that it is group 1 that was different from the older groups; in group 1 the percentage of dissimilated responses is higher than in groups 2 and 3.

Similarly, figure 10 shows a comparison of the percentages of children's correct and dissimilated responses in the word medial condition.

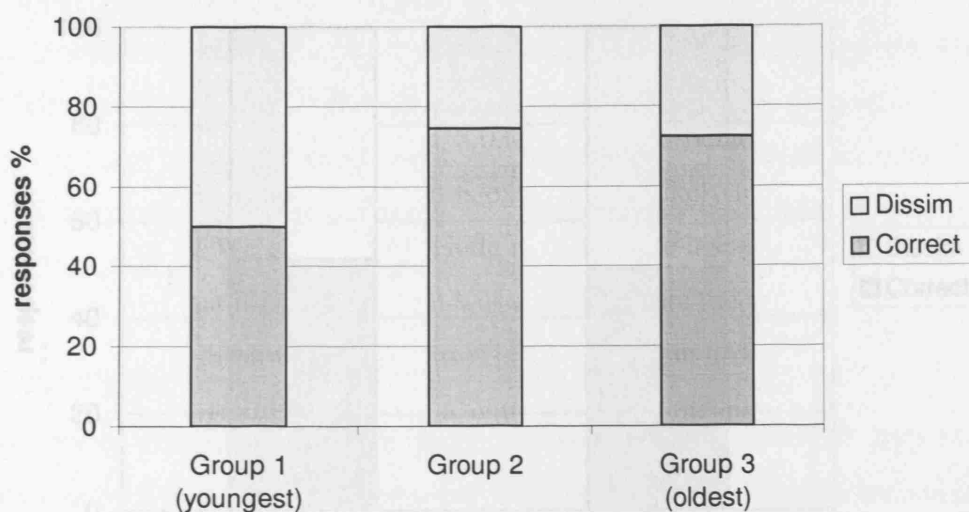


Fig. 10. Percentages of correct and dissimilated responses in word medial position by age group, according to alternative criteria

As in the word initial condition, the ratio between correct and dissimilated responses in group 1 seems to be different from that of the older groups. In a chi-square test performed to test the difference between age groups, a  $\chi^2$  value of 9.532 had an associated probability value of  $p=0.009$ ,  $DF=2$ . We can thus conclude that the difference between the three age groups is statistically significant. Figure 10 shows that it is group 1 – the youngest group – that is different from the older two; moreover, the difference lies in that the percentage of dissimilated responses is higher in group 1 than in groups 2 and 3.

Finally, a comparison of children's performance by social class was carried out. Figure 11 shows the corresponding percentages of correct and dissimilated responses. For detailed results including raw numbers see appendix.

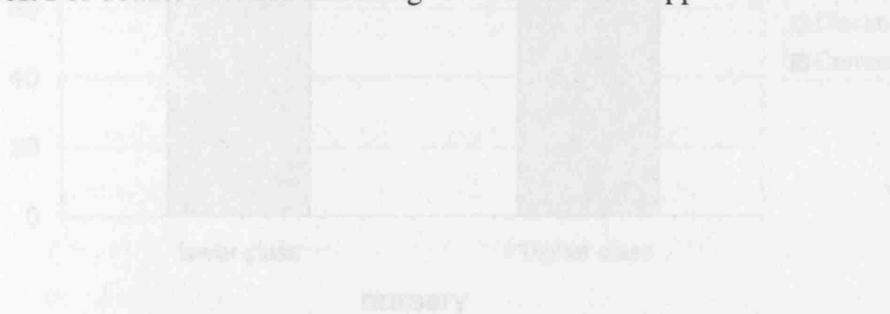


Fig. 11. Percentages of correct and dissimilated responses in word medial position by class, according to alternative criteria

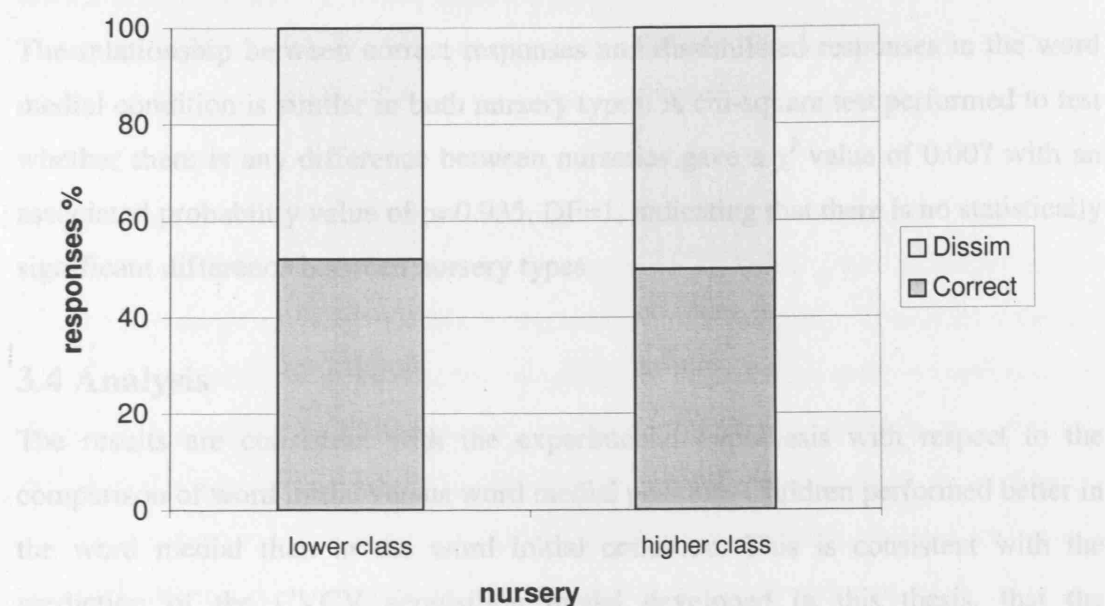


Fig. 11. Percentages of correct and dissimilated responses in word initial position by class, according to alternative criteria

A visual examination of the figure shows that the results are similar across nurseries. A chi-square test performed to test whether there is any difference between the two types of nurseries had a  $\chi^2$  value of 0.030 with an associated probability value of  $p=0.863$ ,  $DF=1$ , indicating that there is no statistically significant difference between nursery types.

Figure 12 shows the same comparison for the word medial condition.

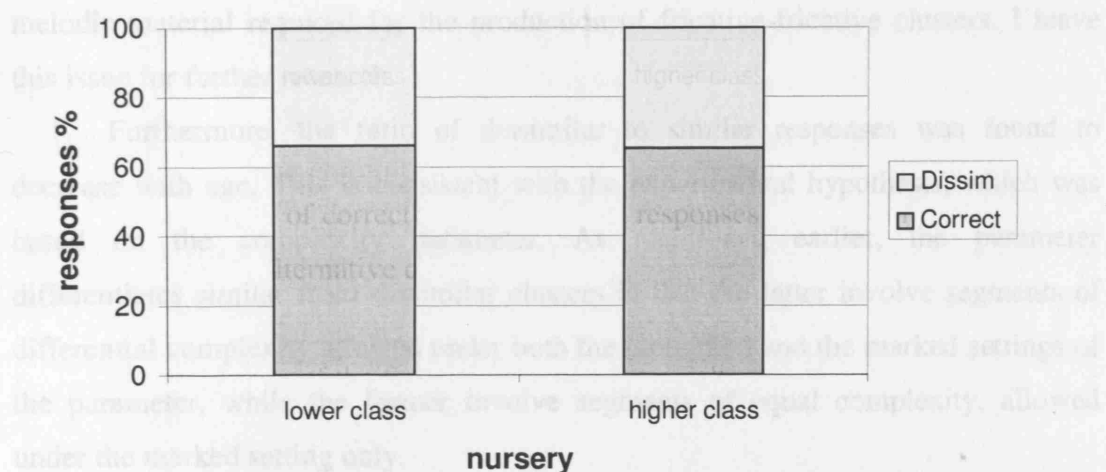


Fig. 12. Percentages of correct and dissimilated responses in word medial position by class, according to alternative criteria

The relationship between correct responses and dissimilated responses in the word medial condition is similar in both nursery types. A chi-square test performed to test whether there is any difference between nurseries gave a  $\chi^2$  value of 0.007 with an associated probability value of  $p=0.935$ ,  $DF=1$ , indicating that there is no statistically significant difference between nursery types.

### 3.4 Analysis

The results are consistent with the experimental hypothesis with respect to the comparison of word initial versus word medial position. Children performed better in the word medial than in the word initial condition. This is consistent with the prediction of the CVCV acquisition model developed in this thesis, that the acquisition of word medial TT clusters precedes that of their word initial counterpart (see chapter 3, section 2).

Children's performance of fricative-fricative clusters in word medial position was considerably poorer than their performance in stop-stop clusters in the same position. This is consistent with the tendency for late acquisition of fricatives documented in first language acquisition studies (see e.g. Jakobson (1968)). The results regarding fricative-fricative clusters thus appear to be due to a combination of segmental and structural reasons. A child's grammar may have the relevant parameter setting that allows consonant clustering (as suggested by the production of stop-stop clusters in that position), while at the same time it does not allow the melodic material required for the production of fricative-fricative clusters. I leave this issue for further research.

Furthermore, the ratio of dissimilar to similar responses was found to decrease with age. This is consistent with the experimental hypothesis, which was based on the complexity parameter. As mentioned earlier, the parameter differentiates similar from dissimilar clusters in that the latter involve segments of differential complexity allowed under both the unmarked and the marked settings of the parameter, while the former involve segments of equal complexity, allowed under the marked setting only.

Notice that any analysis that claims that similar clusters are more marked than dissimilar clusters would make the same prediction, even if the analysis

assumes an alternative internal composition for the segments involved. In this study, I adopt the internal composition of segments proposed in previous research (Pagoni 1993), although ultimately, more acquisitional research is necessary in order to evaluate competing proposals for the composition of segments.

Finally, the experiment revealed no sociolinguistic variation in the application of dissimilation by Greek children. Children from different socioeconomic backgrounds showed the same levels of dissimilation. This does not mean that sociolinguistic factors are not involved in the dissimilation phenomenon in Greek. It is possible that these factors are not manifested in child language because of the uniformly low register of child-directed speech. In any case, controlling for sociolinguistic variables allows us to make sure that we are examining the purely linguistic aspects of cluster acquisition in a reasonably uniform population.

#### **4 Speculations on diachronic change**

Already in the nineteenth century it was argued that the main locus of language change is in language acquisition (Passy (1890) cited in Lightfoot (1999)). The challenge is therefore to find the link between these two. In our case, the task is to reconstruct in a plausible way the diachronic evolution of Greek consonant clusters, bearing in mind that the evolution was the result of some change in speakers' grammars. This would involve determining how it was possible, at some point in history, for the grammars acquired by (ancient) Greek speaking children to be different from the grammar of their parents.

Lightfoot (1991, 1999)<sup>12</sup> proposes a link of language change with language acquisition in a cue-based model, in the spirit of the cue-based acquisition model proposed by Dresher & Kaye (1990) (see chapter 2, section 8.1). On this view, children do not try to match the input; rather, they scan their linguistic environment for cues that determine the setting of a parameter. Each parameter is associated with one cue by Universal Grammar.<sup>13</sup> Lightfoot argues that in cases when children fail to detect the cue for a parameter setting that their parents' language has, the setting

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<sup>12</sup> See also Kroch (2001).

<sup>13</sup> Note that Lightfoot departs from Dresher & Kaye's model, in claiming that there is no default setting for parameters.



changes: children will have a grammar that will generate forms that are different from the ones their parents' grammar generates.

One of the main possible reasons for the children's failure to find a cue is language contact. In situations of language contact, children start getting mixed input, after the addition of a new input language. If the new input language does not have the same setting for a certain parameter as the original input language, the expression of the relevant cue in the overall input will fall. If the expression of the cue falls under a certain threshold, the cue will become undetectable for the children (Lightfoot 1999). Lightfoot goes on to exemplify a case in which language change is a result of language contact: the loss of verb-second in English.

I propose that a similar situation may have occurred in the case of Greek clusters, as a result of language contact. Recall that ancient Greek had the marked setting for the complexity parameter, according to which the number of elements in an unlicensed position must be smaller than or the same as in the adjacent licensed position.

$$39. \beta \leq \alpha$$

The difference between the unmarked and marked setting is the 'the same as' part. This means that the cue for the marked setting of the parameter would be clusters containing an unlicensed position with the same number of elements as the licensed one:  $[\beta = \alpha]$ . A Greek child would scan the input for this cue, and find it in forms containing *pt*, *kt* (and possibly *p<sup>h</sup>t<sup>h</sup>*, *k<sup>h</sup>t<sup>h</sup>*) in word medial and word initial position. The linguist's problem now is to find out why the parameter changed from the marked to the unmarked setting.

Note that the change took place at some point during the first centuries AD, a period of Roman conquest. This was a period of influence and interaction for the two languages, Greek and Latin. Latin became more and more widespread as the power of Rome increased. Koine, the popular Greek of the time, having been the lingua franca of the East, was quite resistant, and did not disappear. Latin-speaking traders, officials and soldiers learned Koine (Horrocks 1997). The long-lasting presence of Romans in the area meant that Greek children of all ages would hear around them Greek, Greek spoken by native speakers of Latin, and some amount of Latin.

What was the structure of Latin, as far as obstruent clusters are concerned? Latin contained *pt* and *kt* clusters in word medial position (examples from Sihler (1995)).

- 40. scriptus (scribō ‘scratch’)
- actus (agō ‘drive’)
- vectus (vehō ‘convey’)
- coctus (coquō ‘cook’)

However, it did not have any such clusters word initially. In fact, loans from Greek with word initial *pt* were altered so that the end result does not contain this cluster (example in 41 from Goetz (1888)).

- 41. *πιτσάνη* (*ptis'anee*) < *tisana* ‘pearl barley’

Both Latin and the Greek spoken by Latin native speakers would contain word medial examples of the cue to the marked setting, but the word initial expression of the cue would not exist in either, since no word initial stop-stop clusters were allowed. As a result, the percentage of cues to the marked setting of the complexity parameter that Greek children would hear dropped, as they mixed with Latin speakers. In Lightfoot’s (1999) terms, it is possible that as a result of these changes the expression of the cue in the overall input fell under a certain threshold. The input was too diluted to be able to cause a change in the setting of the complexity parameter from the unmarked to the marked value in a child’s developing grammar. Therefore, in the grammar of Greek children, the parameter remained in the unmarked setting, according to which the number of elements in the unlicensed position must be lower than the number of elements in the licensed position. The forms with fricative-stop clusters instead of clusters of (voiceless unaspirated or aspirated) stops that were the outcome of this period reflect the unmarked setting of the complexity parameter.

Finally, during the 20<sup>th</sup> century, the setting of the complexity parameter changed back to the marked value. The reasons for this change can be found in the introduction of compulsory schooling and the development of mass media. Both of

these exposed Greek children to masses of compulsory Katharevusa input, which contained the fricative-fricative and stop-stop clusters that could trigger the change to the marked value of the complexity parameter.

## **5 Conclusion**

This chapter was an investigation of the acquisition of fricative-fricative and stop-stop clusters in Greek, and of the related dissimilation phenomenon. The analysis abstracted away from social factors and attempted to tap into the strictly phonological factors at work. It was argued that similar (fricative-fricative /stop-stop) clusters are more marked than dissimilar (fricative-stop) ones. The difference is encoded in a complexity parameter, the two settings of which can be traced in historical and acquisition data.

## CONCLUSIONS AND FUTURE RESEARCH

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The aim of this thesis has been to build a model of the acquisition of consonant clusters, based on the phonological principles and parameters of CVCV theory. According to the model, each cluster is acquired when the relevant parameter(s) switches to the appropriate (marked) value.

A major contribution of the thesis is the light it sheds on the nature of markedness relations in acquisition. Parameter dependencies (or a lack of them) determine the order of acquisition of different cluster types in different positions. This ordering in cluster acquisition is paired with implicational universals in adult language typology.

Predictions of the model were tested with experimental production data from the acquisition of Greek. The following main predictions were borne out by the data. Firstly, the model predicts earlier acquisition of word medial clusters of non-rising sonority (TT), as compared to word initial ones, while no such difference is expected in the acquisition of word medial versus word initial s+obstruent (sT) clusters and word medial versus word initial clusters of rising sonority (TR). Moreover, individual variation in the order of acquisition of word initial sT and word initial TR is predicted (earlier acquisition of sT by some children, earlier acquisition of TR by others), but no overall difference. Both initial sT and initial TR are predicted to be acquired before word initial TT. Finally, variation in the order of acquisition but no overall difference is predicted in the comparison of word medial sT and TR clusters, and in the comparison of word medial TR and word medial sT, TT and RT combined.

Another important aspect of this thesis is its contribution to the evaluation of competing phonological theories. The thesis highlights how first language acquisition provides a valuable testing ground for predictions made by different syllabic theories, including CVCV, Licensing-by-cue and more traditional approaches. In each of the tests presented in this thesis, CVCV was shown to make more accurate predictions than its competitors.

Of particular importance for phonological theory are the findings regarding word initial TT and sT clusters, especially because the acquisition of the former had previously received little attention. It was shown that, contrary to an approach that assigns the same structure to the two cluster types, they behaved differently in acquisition. The order of acquisition is predicted by the CVCV parametric model, which assumes that the necessary and sufficient conditions for initial sT clusters form a proper subset of those for initial TT clusters. More languages that have initial TT clusters need to be investigated in order to test the validity of the findings and generalisations. Testing more languages is also necessary if we are to discover more about the acquisition of consonant sequences and positions that do not occur in Greek, such as word-final clusters.

An important area of focus for further research is the segmental aspect of cluster acquisition. Chapter 5 is an attempt to examine segmental acquisition effects within the CVCV parametric model, by investigating lenition in Greek. However, the internal composition of segments was not discussed in detail. Further research is required to study the role of segment composition in acquisition, especially in connection with positional phenomena that are at the heart of CVCV theory.

Chapter 5 briefly discussed a possible link between language acquisition and language change, within a parametric phonological model. It was argued that evidence for a parameter that was responsible for a diachronic change in Greek phonology can also be found at work in phonological acquisition. An important area for future research is to forge a tighter link between experimental work on phonological acquisition and phonological change.

Finally, yet another contribution of the thesis has been that it has made available new information on what constitutes normal development in the acquisition of Greek consonant clusters. The experimental findings presented here can serve as a baseline against which speech and language therapists can more readily identify atypical patterns of phonological development in Greek.

## References

- Akinlabi, A. 1993. Underspecification and the phonology of Yoruba /r/. *Linguistic Inquiry*. vol. 24. pp. 139-160.
- Anderson, J. & C. Ewen 1987. *Principles of Dependency Phonology*. Cambridge University Press, Cambridge.
- Anderson, S. 1982. The analysis of French schwa: or, how to get something for nothing. *Language*. vol. 58. pp. 534-573.
- Anttila, A. T. 1997. Deriving variation from grammar. In *Variation, change, and phonological theory*, F. Hiskens, R. Van Hout, & L. Wetzels, eds., John Benjamins, Amsterdam, pp. 35-68.
- Anttila, A. T. & Y. Y. Cho 1998. Variation and change in Optimality theory. *Lingua*. vol. 104. pp. 31-56.
- Arvaniti, A. 1991. *The phonetics of Modern Greek and its phonological implications*. Ph.D. Dissertation. University of Cambridge.
- Attias, H. 2001. ICA, graphical models and variational methods. In *Independent component analysis: principles and practice*, S. Roberts & R. Everson, eds., Cambridge University Press, Cambridge, pp. 95-112.
- Backley, P. 1995. A tier geometry for vowel systems. *UCL Working Papers in Linguistics*. vol. 7. pp. 399-436.
- Baertsch, K. & S. Davis 2003. The split margin approach to syllable structure. *ZAS Papers in Linguistics*. vol. 32. pp. 1-14.
- Barlow, J. 1997. *A constraint-based account of syllable onsets: evidence from developing systems*. Ph.D. Dissertation. Indiana University.
- Barlow, J. 2001. The structure of /s/-sequences: evidence from a disordered system. *Journal of Child Language* vol. 28. pp. 291-324.
- Batibo, H. M. 1995. Loanword cluster nativization rules in Tswana and Swahili. *South African Journal of African Languages*. vol. 16. pp. 33-41.
- Bernhardt, B. & J. P. Stemberger (eds.) 1998. *Handbook of phonological development from the perspective of Constraint-based Nonlinear Phonology*. Academic Press, San Diego.
- Berwick, R. C. 1985. *The acquisition of syntactic knowledge*. MIT Press, Cambridge, Mass.

- Blevins, J. 1995. The syllable in phonological theory. In *The handbook of phonological theory*, J. Goldsmith, ed., Blackwell, Cambridge, Mass, pp. 206-244.
- Boersma, P. 1998. *Functional phonology: formalising the interactions between articulatory and perceptual drives*. Ph.D. Dissertation. University of Amsterdam.
- Boersma, P. & B. Hayes 2001. Empirical tests on the gradual learning algorithm. *Linguistic Inquiry*. vol. 32. pp. 45-86.
- Borer, H. & K. Wexler 1987. The maturation of syntax. In *Parameter setting*, T. Roeper & E. Williams, eds., Reidel, Dordrecht.
- Browning, R. 1983. *Medieval and Modern Greek*. Cambridge University Press, Cambridge.
- Cairns, C. E. 1988. Phonotactics, markedness and lexical representations. *Phonology*. vol. 5. pp. 209-236.
- Carr, P. 1993. *Phonology*. Macmillan, Houndmills and London.
- Charette, M. 1990. Licence to govern. *Phonology Yearbook*. vol. 7.2. pp. 233-253.
- Charette, M. 1991. *Conditions on phonological government*. Cambridge University Press, Cambridge.
- Charette, M. & A. Göksel 1994. Vowel harmony and switching in Turkic languages. *SOAS working papers in Linguistics and Phonetics*. vol. 4. pp. 31-52.
- Charette, M. & A. Göksel 1996. Licensing constraints and vowel harmony in Turkic languages. *SOAS working papers in Linguistics and Phonetics*. vol. 6. pp. 1-25.
- Chin, S. B. 1996. The role of the sonority hierarchy in delayed phonological systems. In *Pathologies of speech and language: contributions of clinical phonetics and linguistics*, T. Powell, ed., International Clinical Phonetics and Linguistics Association, New Orleans, pp. 109-117.
- Chomsky, N. 1959. A review of B. F. Skinner's *Verbal Behavior*. *Language*. vol. 35. pp. 26-58. Reprinted in B. Lust & C. Foley, eds., *First Language acquisition: the essential readings*. 2004. Blackwell, Oxford.
- Chomsky, N. 1981. *Lectures on Government and Binding*. Foris, Dordrecht.
- Chomsky, N. 1986. *Knowledge of language: its nature, origin and use*. Praeger, New York.

- Chomsky, N. & M. Halle 1968. *The sound pattern of English*. MIT Press, Cambridge, MA.
- Clements, G. 1990. The role of sonority cycle in core syllabification. In *Papers in Laboratory phonology I*, J. Kingston & M. Beckmann, eds., Cambridge University Press, Cambridge, pp. 283-333.
- Clements, G. 1992. The sonority cycle and syllable organization. In *Phonologica 1988*, W. Dressler, H. Luschützky, O. Pfeiffer, and J. Rennison, eds., Cambridge University Press, Cambridge, pp. 63-76.
- Cyran, E. 2003. *Complexity scales and licensing strength in phonology*. Wydawnictwo KUL, Lublin.
- Davis, S. 1990. Italian onset structure and the distribution of *il* and *lo*. *Linguistics*. vol. 28. pp. 43-55.
- Davis, S. & K. Baertsch 2006. A syllable-based approach to strength relations between consonants: an Optimality-Theoretic perspective. Talk given at the *Workshop: strength relations in phonology*, Tohoku Gakuin University, Sendai.
- Dehaene-Lambertz, G., E. Dupoux, & A. Gout 2000. Electrophysiological correlates of phonological processing: a cross-linguistic study. *Journal of cognitive neuroscience*. vol. 12. pp. 635-647.
- Dell, F. 1995. Consonant clusters and phonological syllables in French. *Lingua*. vol. 95. pp. 5-26.
- Demuth, K. 1996. Alignment, stress and parsing in the construction of early prosodic words. In *Proceedings of the UBC international conference on phonological acquisition*, B. Bernhardt, J. Gilbert, & D. Ingram, eds., Cascadia Press, Somerville, pp. 136-148.
- Demuth, K. & M. M. Kehoe 2006. The acquisition of word-final clusters in French. *Catalan Journal of Linguistics*. vol. 5. pp. 59-81.
- Dixon, R. M. W. & A. Y. Aikhenvald 1999. *The Amazonian languages*. Cambridge University Press, Cambridge.
- Dollaghan, C. & T. F. Campbell 1998. Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research*. vol. 41. pp. 1136-1146.



- Drachman, G. & A. Malikouti-Drachman 1999. Greek word accent. In *Word prosodic systems in the languages of Europe*, H. van der Hulst, ed., Mouton de Gruyter, Berlin, pp. 897-945.
- Dresher, B. E. 1996. The rise of Optimality Theory in first century Palestine. *Glot International*. vol. 2. p. 8.
- Dresher, B. E. 1999. Charting the learning path: Cues to parameter setting. *Linguistic Inquiry*. vol. 30. pp. 27-67.
- Dresher, B. E. & J. Kaye 1990. A computational learning model for metrical phonology. *Cognition*. vol. 34. pp. 137-195.
- Dupoux, E., K. Kakehi, Y. Hirose, C. Pallier, & J. Mehler 1999. Epenthetic vowels in Japanese: a perceptual illusion? *Journal of experimental psychology: Human perception and performance*. vol. 25. pp. 1568-1578.
- Eilers, R. E. & D. K. Oller 1976. The role of speech discrimination in developmental sound substitutions. *Journal of child language*. vol. 3. pp. 319-329.
- Ewen, C. & H. van der Hulst 2001. *The phonological structure of words: an introduction*. Cambridge University Press, Cambridge.
- Fee, J. 1995. Segments and syllables in early language acquisition. In *Phonological acquisition and phonological theory*, J. Archibald, ed., Lawrence Erlbaum, Hillsdale, New Jersey.
- Ferguson, C. A. 1959. Diglossia. *Word*. vol. 15. pp. 325-340.
- Fikkert, P. 1994. *On the acquisition of prosodic structure*. HIL Dissertations, Dordrecht.
- Frey, B. & G. E. Hinton 1999. Variational learning in nonlinear Gaussian belief networks. *Neural Computation*. vol. 11. pp. 193-214.
- Gathercole, S. 1995. Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory and Cognition*. vol. 23. pp. 83-94.
- Gathercole, S. E., C. Willis, A. D. Baddeley, & H. Emslie 1994. The children's test of nonword repetition: a test of phonological working memory. *Memory*. vol. 2. pp. 103-127.
- Gibson, E. & K. Wexler 1994. Triggers. *Linguistic Inquiry*. vol. 25. pp. 407-454.
- Gierut, J. 1999. Syllable onsets: clusters and adjuncts in acquisition. *Journal of Speech, Language, and Hearing Research*. vol. 42. pp. 708-726.

- Gnanadesikan, A. 1995. *Markedness and faithfulness constraints in child phonology*. ROA 67.
- Gnanadesikan, A. 2004. Markedness and faithfulness constraints in child phonology. In *Constraints in phonological acquisition*, R. Kager, J. Pater, & W. Zonneveld, eds., Cambridge University press, Cambridge, pp. 73-108.
- Goad, H. 1998. On the status of final consonants in early child language. In *Proceedings of the 22nd annual Boston University conference on canguage development*, A. Greenhill, M. Hughes, H. Littlefield, and H. Walsh, eds., Cascadilla Press, Somerville, MA, pp. 269-280.
- Goad, H. & K. Brannen 2000. Syllabification at the right edge of words: parallels between child and adult grammars. In *Issues in the phonology-phonetics interface*, J. van de Weijer, ed., John Benjamins, Amsterdam.
- Goad, H. & Y. Rose 2003. Input elaboration, head faithfulness and evidence for representation in the acquisition of left-edge clusters in West Germanic. In *Constraints in phonological acquisition*, R. Kager, J. Pater, & W. Zonneveld, eds., Cambridge University press, Cambridge.
- Goetz, G. & G. Loewe 1888. *Corpus Glossariorum Latinorum*. Teubner, Leipzig, repr. Hakkert, Amsterdam, 1965.
- Goldsmith, J. 1990. *Autosegmental and metrical phonology*. Blackwell, Oxford.
- Grammont, M. 1914. *Traité pratique de prononciation française*. Delgrave, Paris.
- Greenberg, J. H. 1978. Some generalisations concerning initial and final consonant clusters. In *Universals of human language. Volume 2 Phonology*, J. H. Greenberg, ed., Stanford University Press, Stanford, California, pp. 243-277.
- Gussmann, E. 1980. *Studies in abstract phonology*. MIT Press, Cambridge, MA.
- Gussmann, E. & J. Harris 1998. Final codas: why the west was wrong. In *Structure and interpretation. Studies in Phonology*, E. Cyran, ed., Folium, Lublin, pp. 139-162.
- Gussmann, E. & J. Harris 2002. Word-final onsets. *UCL Working Papers in Linguistics*. vol. 14. pp. 1-42.
- Hale, M. & C. Reiss 1998. Formal and empirical arguments concerning phonological acquisition. *Linguistic Inquiry*. vol. 29. pp. 656-683.
- Halle, M. & J.-R. Vergnaud 1980. Three-dimensional phonology. *Journal of Linguistic Research*. vol. 1. pp. 83-105.

- Harris, J. 1990. Segmental complexity and phonological government. *Phonology*. vol. 7. pp. 255-300.
- Harris, J. 1994. *English sound structure*. Blackwell, Oxford.
- Harris, J. 1997. Licensing Inheritance: an integrated theory of neutralisation. *Phonology*. vol. 14. pp. 315-370.
- Harris, J. 1999. Release the captive coda: the foot as a domain of phonetic interpretation. *UCL Working Papers in Linguistics*. vol. 11.
- Harris, J. 2006. The phonology of being understood: further arguments against sonority. *Lingua*. vol. 116. pp. 1483-1494.
- Harris, J. & G. Lindsey 1995. The elements of phonological representation. In *Frontiers of phonology: atoms, structures, derivations*, J. Durand & F. Katamba, eds., Longman, London.
- Horrocks, G. C. 1997. *Greek: a history of the language and its people*. Longman Linguistics Library, London and New York.
- Hyman, L. 1970. The role of borrowings in the justification of phonological grammars. *Studies in African linguistics*. vol. 1. pp. 1-48.
- Ingram, D. 1986. Phonological development: production. In *Language acquisition. Studies in first language development*, P. Fletcher & M. Garman, eds., Cambridge University Press, Cambridge, pp. 223-239.
- Itô, J. 1986. *Syllable theory in Prosodic Phonology*. PhD Dissertation, University of Massachusetts. Amherst.
- Itô, J. & P. Mester 1995. Japanese phonology. In *Handbook of phonological theory*, J. Goldsmith, ed., Blackwell, Oxford.
- Jakobson, R. 1968. *Child language, aphasia and phonological universals*. Mouton, Hague and Paris.
- Jongstra, W. 2003. *Variation in reduction strategies of Dutch word-initial consonant clusters*. Ph.D. Dissertation. University of Toronto.
- Joseph, B. D. & I. Philippaki-Warbuton 1987. *Modern Greek*. Croom Helm, London.
- Kappa, I. 2002. On the acquisition of syllabic structure in Greek. *Journal of Greek Linguistics*. vol. 3. pp. 1-52.
- Kaye, J. 1990. 'Coda' Licensing. *Phonology Yearbook*. vol. 7.2. pp. 301-330.
- Kaye, J. 1992. Do you believe in magic? The story of s+C sequences. *SOAS working papers in Linguistics and Phonetics*. vol. 2. pp. 293-313.

- Kaye, J. 2001. Working with licensing constraints. In *Constraints and preferences*, K. Dziubalska-Kolaczyk, ed., Mouton de Gruyter, Berlin & New York.
- Kaye, J. & J. Lowenstamm 1981. Syllable structure and Markedness theory. In *Theory of markedness in generative grammar. Proceedings of the 1979 GLOW conference*, A. Beletti, L. Brandi, & L. Rizzi, eds., Scuola normale superiore, Pisa, pp. 287-315.
- Kaye, J., J. Lowenstamm, & J.-R. Vergnaud 1985. The internal structure of phonological representations: a theory of Charm and Government. *Phonology Yearbook*. vol. 2. pp. 305-328.
- Kaye, J., J. Lowenstamm, & J.-R. Vergnaud 1990. Constituent structure and government in phonology. *Phonology Yearbook*. vol. 7.2. pp. 193-231.
- Kaye, J. & B. Nykiel 1979. Loan words and abstract phonotactic constraints. *Canadian Journal of Linguistics*. vol. 24. pp. 71-93.
- Kaye, J. D. 1985. On the syllable structure of certain West African languages. In *African linguistics: essays in memory of M. W. K. Semikenke*, D. Goyvaerts, ed., John Benjamins, Philadelphia, pp. 285-307.
- Kazazis, K. 1992. Sunday Greek revisited. *Journal of Modern Greek Studies*. vol. 10. pp. 57-69.
- Kehoe, M. M. & C. Stoel-Gammon 2001. Development of syllable structure in English-speaking children with particular reference to rhymes. *Journal of child language*. vol. 28. pp. 393-432.
- Kenstowicz, M. 2003. The role of perception in loanword phonology. A review of Les emprunts linguistiques d'origine européenne en Fon. *Studies in African linguistics*. vol. 32. pp. 95-112.
- Kenstowicz, M. & J. Rubach 1987. The phonology of syllabic nuclei in Slovak. *Language*. vol. 63. p. 497.
- Kirk, C. & K. Demuth 2003. Onset/Coda asymmetries in the acquisition of clusters. In *Proceedings of the 27<sup>th</sup> Boston University conference on language development*, B. Beachley, A. Brown, and F. Conlin, eds., Cascadia Press, Somerville, pp. 437-448.
- Kirk, C. & K. Demuth 2005. Asymmetries in the acquisition of word-initial and word-final consonant clusters. *Journal of child language*. vol. 32. pp. 709-734.
- Kirk, C. & K. Demuth 2006. Accounting for variability in 2-year-olds' production of coda consonants. *Language learning and development*. vol. 2. pp. 97-118.

- Kroch, A. 2001. Syntactic change. In *The handbook of contemporary syntactic theory*, M. Baltin & C. Collins, eds., Blackwell, Oxford, pp. 699-729.
- Kula, N. C. 2006. No initial empty CV in clusterless languages. *Linguistics in the Netherlands*. vol 23. pp. 137-149.
- Kula, N. C. 2005. On licensing constraints for consonants. In *Papers in Government Phonology. Special Issue of Leiden Papers in Linguistics 2.4*, N. C. Kula & Jeroen van de Weijer, eds., pp. 51-75.
- Kula, N. C. & L. Marten 2006. *Strength or not, in initial position*. Talk given at the *Workshop: strength relations in phonology*, Tohoky Gakuin University, Sendai.
- Ladefoged, P. 1975. *A course in phonetics*. Harcourt, Brace, Jovanovich, New York.
- Laskowski, R. 1975. *Studia nad morfonologia współczesnego języka polskiego*. Wydawnictwi Polskiej Akademii Nauk, Wrocław, Warszawa, Kraków, Gdansk.
- Laws, G. 1998. The use of nonword repetition as a test of phonological memory in children with Down syndrome. *Journal of Child Psychology and Psychiatry*. vol. 39. pp. 1119-1130.
- Levelt, C. 1994. *On the acquisition of place*. Holland Academic Graphics, The Hague.
- Levelt, C. & R. van de Vijver 2004. Syllable types in cross-linguistic and developmental grammars. In *Constraints in phonological acquisition*, R. Kager, J. Pater, & W. Zonneveld, eds., Cambridge University Press, Cambridge, pp. 204-218.
- Levelt, C., N. Schiller, & W. Levelt 2000. The acquisition of syllable types. *Language Acquisition*. vol. 8. pp. 237-264.
- Levin, J. 1985. *A metrical theory of syllabicity*. Ph.D. Dissertation. MIT.
- Lightfoot, D. W. 1991. *How to set parameters: evidence from language change*. MIT Press, Cambridge, MA.
- Lightfoot, D. W. 1999. *The development of language: acquisition, change and evolution*. Blackwell, Malden, MA.
- Lin, J. T.-H. 1998. *From transliteration to grammar: a study of adaptation of foreign names into Chinese and Taiwanese Mandarin*. Ms, UC Irvine.
- Lin, Y.-H. 1997. Syllabic and moraic structures in Piro. *Phonology*. vol. 14. pp. 403-436.

- Lleó, C. & M. Prinz 1997. Syllable structure parameters and the acquisition of affricates. In *Focus on phonological acquisition*, M. Young-Scholten & S. J. Hannas, eds., John Benjamins, Philadelphia, pp. 143-164.
- Lowenstamm, J. 1996. CV as the only syllable type. In *Current trends in phonology. Models and methods*, J. Durand & B. Laks, eds., ESRI, Salford, Manchester, pp. 419-441.
- Lowenstamm, J. 1999. The beginning of the word. In *Phonologica 1996*, J. Rennison & K. Kühnhammer, eds., Holland Academic Graphics, La Hague, pp. 153-166.
- Macken, M. A. 1980. The child's lexical representation: the puzzle-puddle-pickle evidence. *Journal of Linguistics*. vol. 16. pp. 1-17.
- Mackridge, P. 1985. *The Modern Greek language*. Oxford University Press, Oxford.
- MacWhinney, B. 2000. *The CHILDES database: Tools for analysing talk, Volume 2: The database*. Lawrence Erlbaum Associates, (3rd ed.). Mahwah, NJ.
- Malikouti-Drachman, A. 1987. Syllables in Modern Greek. In *Phonologica 1984*, W. Dressler, H. Luschützky, O. Pfeiffer, and J. Rennison, eds., Cambridge University Press, London, pp. 181-187.
- Malikouti-Drachman, A. & G. Drachman 1989. Tonismos sta Ellinika [Stress in Greek]. In *Studies in Greek linguistics*, University of Thessaloniki, Thessaloniki, pp. 127-143.
- Marcus, M. P. 1980. *A theory of syntactic recognition for natural language*. MIT Press, Cambridge, MA.
- Menn, L. 1971. Phonotactic rules in beginning speech. *Lingua*. vol. 26. pp. 225-241.
- Menn, L. 1978. Phonological units in beginning speech. In *Syllables and segments*, A. Bell & J. B. Hooper, eds., North-Holland, Amsterdam.
- Menn, L. & E. Matthei 1992. The 'Two-Lexicon' account of child phonology: looking back, looking ahead. In *Phonological development: models, research, implications*, C. Ferguson, L. Menn, & C. Stoel-Gammon, eds., York Press, Timonium, MD.
- Migliazza, E. C. 1972. *Yanomama grammar and intelligibility*. Ph.D. Dissertation. Indiana University.
- Miller, S. & H. Fox 1994. Automatic grammar acquisition. In *Proceedings of the human language technology workshop*, pp. 268-271.

- Milliken, W., B. Albert, M. de Lourdes Ruivo, F.-M. Le Tourneau, & R. Duarte 2002. *Degraded areas in the Yanomami territory, Roraiwa, Brazil. Ethno-environmental evaluation of the Homoxi region.* The nature conservancy. Available on: [www.proyanomami.org.br/frame1/noticia.asp?id=1388](http://www.proyanomami.org.br/frame1/noticia.asp?id=1388).
- Morelli, F. 1999. *The phonotactics and phonology of obstruent clusters in Optimality Theory.* Ph.D. Dissertation. University of Maryland.
- Murray, R. W. & T. Vennemann 1983. Sound change and syllable structure in Germanic phonology. *Language*. vol. 59. pp. 514-528.
- Nasukawa, K. 1995. Nasality and harmony in Gokana. *UCL Working Papers in Linguistics*. vol. 7. pp. 511-533.
- Nasukawa, K. 2005. *A unified approach to nasality and voicing.* Mouton de Gruyter, Berlin & New York.
- Newton, B. 1972. *The generative interpretation of dialect: a study of Modern Greek phonology.* Cambridge University Press, London.
- Ohala, D. 1998. Medial cluster reduction in early child speech. In *The proceedings of the twenty-ninth annual child language research forum*, E. V. Clark, ed., pp. 111-120.
- Ohala, D. 1999. The influence of sonority on children's cluster reductions. *J. Commun. Disord.* vol. 32. pp. 397-422.
- Pagoni, S. 1993. *Modern Greek phonological variation: a government phonology approach.* Ph.D. Dissertation. University College London.
- Pagoni-Tetlow, S. 1998. Breaking up is (not) hard to do: the case of the Modern Greek *pt/kt* sequences. In *Themes in Greek Linguistics II*, B. D. Joseph, G. C. Horrocks, & I. Philippaki-Warbuton, eds., John Benjamins, Amsterdam.
- Pan, N. 2005. *A Government Phonology approach to the acquisition of syllable structure.* Ph.D. Dissertation. University of Louisiana at Lafayette.
- Pan, N. & W. Snyder 2003. Setting the parameters of syllable structure in early child Dutch. In *Proceedings of the 27th Boston University conference on language development, Volume 2*, B. Beachley & F. Conlin, eds., Cascadilla Press, Somerville, MA, pp. 615-125.
- Pan, N. & W. Snyder 2004. Acquisition of /s/-initial clusters: a parametric approach. In *Proceedings of the 28th Boston University conference on language*

- development*, A. Brugos, L. Micciulla, & C. E. Smith, eds., Cascadilla press, Somerville, MA, pp. 436-446.
- Paradis, C. & D. LaCharité 1997. Preservation and minimality in loanword adaptation. *Journal of Linguistics*. vol. 33. pp. 379-430.
- Paradis, C. & D. LaCharité 2001. Guttural deletion in loanwords. *Phonology*. vol. 18. pp. 225-300.
- Park, W. 1987. *Western loan-words in Japanese*. Stockholm Universitet.
- Parker, S. G. 2002. *Quantifying the sonority hierarchy*. Ph.D. Dissertation. University of Massachusetts.
- Passy, P. 1890. *Étude sur les changements phonétiques et leurs caractères généraux*. Firmin-Didot, Paris.
- Pater, J. 1997. Minimal violation and phonological development. *Language Acquisition*. vol. 6. pp. 201-253.
- Pater, J. & J. Barlow 2003. Constraint conflict in cluster reduction. *Journal of child language*. vol. 30. pp. 487-526.
- Peperkamp, S. (to appear). A psycholinguistic theory of loanword adaptation. In *Proceedings of the 30th annual meeting of the Berkeley linguistics society*.
- Peperkamp, S. & E. Dupoux 2003. Reinterpreting loanword adaptations: the role of perception. In *Proceedings of the 15th International congress of phonetic sciences*, Barcelona, pp. 367-370.
- Philippaki-Warbuton, I. 1976. On the boundaries of morphology and phonology: a case study from Greek. *Journal of Greek Linguistics*. vol. 12. pp. 259-278.
- Pierrehumbert, J. B. 2001. Stochastic Phonology. *Glott International*. vol. 5. pp. 195-207.
- Piggott, G. 1991. Apocope and the licensing of empty-headed syllables. *The Linguistic Review*. vol. 8. pp. 187-318.
- Piggott, G. 1999. At the right edge of words. *The Linguistic Review*. vol. 16. pp. 143-185.
- Pinker, S. 1984. *Language learnability and language development*. Harvard University Press, Cambridge, MA.



- Ploch, S. 2003. Metatheoretical problems in phonology with Occam's Razor and non-ad-hocness. In *Living on the edge: 28 papers in honour of Jonathan Kaye*, S. Ploch, ed., Mouton de Gruyter, Berlin, New York, pp. 149-201.
- Polgárdi, K. 1999. Constraint ranking, government licensing and the fate of final empty nuclei. In *Phonologica 1996*, J. Rennison & K. Kühnhammer, eds., Holland Academic Graphics, The Hague, pp. 167-182.
- Polgárdi, K. 2003. Hungarian as a Strict CV language. In *The phonological spectrum. Vol II: Suprasegmental structure*, H. van der Hulst, V. van Heuven, & J. van de Weijer, eds., Benjamins, Amsterdam and Philadelphia, pp. 59-79.
- Prince, A. & P. Smolensky 1993. *Optimality Theory: constraint interaction in generative grammar*. Ms., Rutgers University, New Brunswick and University of Colorado, Boulder.
- Radford, A. 1990. *Syntactic theory and the acquisition of English syntax*. Blackwell, Oxford.
- Ralli, A. 1988. *Éléments de morphologies du Grec Moderne*. Ph.D. Dissertation. Université de Montreal.
- Rennison, J. 1999a. Can there be empty phonological elements? On empty heads and empty operators. In *Phonologica 1996*, J. Rennison & K. Kühnhammer, eds., Holland Academic graphics, The Hague, pp. 183-193.
- Rennison, J. 1999b. Syllables in Western Koromfe. In *The syllable, views and facts*, H. van der Hulst & N. A. Ritter, eds., de Gruyter, Berlin, New York, pp. 311-347.
- Rennison, J. 2000. OT and TO: on the status of OT as a theory and a formalism. *The Linguistic Review*. vol. 17. pp. 135-141.
- Revithiadou, A. 1999. *Headmost accent wins*. Ph.D. Dissertation. LOT.
- Rice, K. D. 1992. On deriving sonority: a structural account of sonority relationships. *Phonology*. vol. 9. pp. 61-99.
- Roca, I. 1994. *Generative phonology*. Routledge, London.
- Rose, Y. 1999a. A structural account of root node deletion in loanword phonology. *Canadian Journal of Linguistics*. vol. 44. pp. 359-404.
- Rose, Y. 1999b. Perception, representation, and correspondence relations in loanword phonology. In *Proceedings of the 25th annual meeting of the Berkeley linguistics society*, S. S. Chang, L. Liaw, & J. Ruppenhofer, eds., Berkeley, CA, pp. 383-394.

- Rose, Y. 2000. *Headedness and prosodic licensing in the L1 acquisition of phonology*. Ph.D. dissertation. McGill University, Montreal.
- Rose, Y. 2001. Licensing and feature interaction processes in child language. In *WCCFL 20 Proceedings*, Cascadilla Press, Somerville, MA, pp. 484-497.
- Rose, Y. 2003. Chilphon: a database solution for the study of child language. In *Proceedings of the Boston University conference on language development*, Cascadilla Press, Somerville, MA.
- Rowicka, G. 1999. *On ghost vowels*. Ph.D. Dissertation. Leiden University.
- Rubach, J. 1984. *Cyclic and Lexical Phonology: the structure of Polish*. Foris, Dordrecht.
- Rubach, J. 1993. *The Lexical Phonology of Slovak*. Clarendon Press, Oxford.
- Rubach, J. & G. Booij 1990. Edge of constituent effects in Polish. *Natural language and linguistic theory*. vol. 8. pp. 427-463.
- Saussure, F. d. 1916. *Cours de la linguistique générale*. Payot, Lausanne and Paris.
- Schane, S. A. 1968. *French phonology and morphology*. MIT Press, Cambridge, Mass.
- Schane, S. A. 1984. The fundamentals of Particle Phonology. *Phonology Yearbook*. vol. 1. pp. 129-155.
- Scheer, T. 1996. *Une théorie de l'interaction directe entre consonnes*. Ph.D. Dissertation. Université Paris 7.
- Scheer, T. 1999. A theory of consonantal interaction. *Folia Linguistica*. vol. 32. pp. 201-237.
- Scheer, T. 2000a. *De la localité, de la morphologie et de la phonologie en phonologie*. Habilitation thesis. University of Nice.
- Scheer, T. 2000b. L'immunité de schwa en début de mot. *Langue Française*. vol. 126. pp. 113-126.
- Scheer, T. 2004. *A lateral theory of phonology. Volume 1: What is CVCV, and why should it be?* Mouton de Gruyter, Berlin.
- Scobbie, J. M. 1997. *Autosegmental representation in a Declarative Constraint-based framework*. Garland Press, New York.
- Ségéral, P. & T. Scheer 2001. La Coda-Miroir. *Bulletin de la Société de Linguistique de Paris*. vol. 96. pp. 107-152. English version on <http://www.unice.fr/dsl/tobias.htm>.

- Seigneur-Froli, D. 2003. Diachronic consonantal lenition & exotic word-initial clusters in Greek: a unified account. In *Studies in Greek linguistics 23. Proceedings of the 23rd annual meeting of the department of linguistics of AUTH*, M. Stavrou-Sifaki & A. Fliatouras, eds., Faculty of Philosophy, Aristotle University of Thessaloniki, Thessaloniki, pp. 345-357.
- Seigneur-Froli, D. 2004. Greek *ptero*: neither extrasyllabicity nor magic. In *Phonologica 2002*, J. Rennison, F. Neubarth, & M. A. Pöchtrager, eds., Vienna.
- Seigneur-Froli, D. 2006. *Statut phonologique du début de mot grec*. Ph.D. Dissertation. Université de Nice Sofia-Antipolis.
- Seigneur-Froli, D. & E. Sanoudaki in preparation. The acquisition of consonant clusters in French.
- Selkirk, E. 1982. The syllable. In *The structure of phonological representations, Part 2*, H. van der Hulst & N. Smith, eds., Foris, Dordrecht, pp. 337-383.
- Selkirk, E. 1984. On the major class features and syllable theory. In *Language sound structure*, M. Aronoff & R. Oehrle, eds., MIT Press, Cambridge, Mass, pp. 107-136.
- Shieber, S. M. 1983. Sentence disambiguation by a shift-reduce parsing technique. In *Proceedings of the 21st annual meeting of the association for computational linguistics*, Cambridge, Mass, pp. 113-118.
- Sihler, A. 1995. *New Comparative Grammar of Latin and Greek*. Oxford University Press, Oxford.
- Singh, R. 1987. Well-formedness conditions and phonological theory. In *Phonologica 1986*, W. Dressler, ed., Cambridge University Press, Cambridge, pp. 237-286.
- Smit, A. 1993. Phonologic error distributions in Iowa-Nebraska articulation norms project: word initial consonant clusters. *Journal of Speech, Language, and Hearing Research*. vol. 36. pp. 931-947.
- Smith, N. 2003. Are gucks mentally represented? *Glott International*. vol. 7. pp. 164-166.
- Smith, N. V. 1973. *The acquisition of phonology, a case study*. Cambridge University Press, Cambridge.
- Spencer, A. 1986a. Towards a theory of phonological development. *Lingua*. vol. 68. pp. 3-38.

- Spencer, A. 1986b. A non-linear analysis of vowel zero alternations in Polish. *Journal of Linguistics*. vol. 22. pp. 249-280.
- Stampe, D. 1969. The acquisition of phonetic interpretation. In *Proceedings of the 5th regular meeting of the Chicago Linguistic Society*, Chicago Linguistic Society. Reprinted in B. Lust & C. Foley eds., *First language acquisition: the essential readings*. 2004. Blackwell, Oxford, pp. 443-454.
- Steriade, D. 1982. *Greek prosodies and the nature of syllabification*. Ph.D. Dissertation. Garland Press.
- Steriade, D. 1994. Complex onsets as single segments: The Mazateco pattern. In *Perspectives in phonology*, J. Cole & C. Kisseberth, eds., CSLI, Stanford, CA, pp. 203-291.
- Steriade, D. 1997. *Phonetics in phonology: the case of laryngeal neutralisation*. Ms., University of California, Los Angeles. Available on <http://www.linguistics.ucla.edu/people/steriade/papers/phoneticsinphonology.pdf>.
- Steriade, D. 2001. Directional asymmetries in place assimilation: a perceptual account. In *The role of speech perception in phonology*, E. Hume & K. Johnson, eds., Academic Press, New York, pp. 219-250.
- Szigetvári, P. 1994. Coronality, Velarity and why they are special. *The Even Yearbook*. vol. 1. pp. 185-224.
- Szigetvári, P. 1999. *VC Phonology: a theory of consonant lenition and phonotactics*. Ph.D. Dissertation. Eötvös Loránd University.
- Takahashi, T. 1993. A farewell to constituency. *UCL Working Papers in Linguistics*. vol. 5.
- Takahashi, T. 2004. *Syllable theory without syllables*. Ph.D. Dissertation. University College London.
- Tesar, B. & P. Smolensky 1998. Learnability in Optimality Theory. *Linguistic Inquiry*. vol. 29. pp. 229-268.
- Tesar, B. & P. Smolensky 2000. *Learnability in Optimality Theory*. MIT Press, Cambridge, MA.
- Tranel, B. 1987. Floating schwas and closed syllable adjustment in French. In *Phonologica 1984*, W. Dressler, H. Luschützky, O. Pfeiffer, and J. Rennison, eds., Cambridge University Press, London, pp. 311-317.

- Trudgill, P. 1983. *On dialect: social and geographical perspectives*. Blackwell, Oxford.
- Tserdanelis, G. 2001. A perceptual account for manner dissimilation in Greek. *Ohio State University Working Papers in Linguistics*. vol. 56.
- Tzakosta, M. 1999. *The acquisition of prosodic structure in Modern Greek. Summary of M.A. thesis*. University of Crete, Rethymno.
- Tzakosta, M. 2001. I pragmatwsi tw n sumfwnikwn sumblegmatwn ston paidiko logo. In *Proceedings of the 21st annual meeting of Greek Linguistics*, Faculty of Philosophy, Aristotle University of Thessaloniki, Thessaloniki, pp. 736-746.
- Tzakosta, M. 2003a. Deletion and Insertion: Two Pathways Towards Optimality. In *Proceedings of the 15th International Symposium on Theoretical and Applied Linguistics*, E. Mela-Athanasopoulou, ed., School of English, Aristotle University of Thessaloniki, Thessaloniki, Greece, pp. 259-271.
- Tzakosta, M. 2003b. Four of a kind: stress patterns in child language. In *Proceedings of the 23rd annual meeting of Greek linguistics*, Faculty of philosophy, Aristotle University of Thessaloniki, Thessaloniki, pp. 467-478.
- Tzakosta, M. 2004. *Multiple parallel grammars in the acquisition of stress in Greek L1*. Ph.D. Dissertation. LOT.
- Uffmann, C. 1999. Vowel epenthesis in loanword adaptation. Talk given at the *Toronto workshop on phonology*, Montréal.
- Uffmann, C. 2001. Patterns of vowel epenthesis (not only) in Shona loanwords. In *Proceedings of HILP5*.
- Uffmann, C. 2004. *Vowel epenthesis in loanword phonology*. Ph.D. Dissertation. Philipps-Universität Marburg.
- Ulrich, C. H. 1997. Loanword adaptation in Lama: testing the TCRS model. *Canadian Journal of Linguistics*. vol. 42. pp. 415-463.
- Valdman, A. 1972. The loi de position as a pedagogical norm. In *Papers in Linguistics and phonetics to the memory of Pierre Delattre*, A. Valdman, ed., Mouton, The Hague, Paris, pp. 473-485.
- van der Hulst, H. & N. A. Ritter 2000. The SPE-heritage of OT. *The Linguistic Review*. vol. 17. pp. 259-290.

- van der Lely, H. K. J. & D. Howard 1993. Children with specific language impairment: linguistic impairment or short-term memory deficit? *Journal of speech and hearing research*. vol. 36. pp. 1193-1207.
- Vanderweide, T. 2005a. *Cue-based learning and the acquisition of pre-vocalic clusters*. Ph.D. Dissertation. University of Calgary.
- Vanderweide, T. 2005b. The acquisition of manner in pre-vocalic sequences: a cue is a cue. In *Developmental paths in phonological acquisition. Special Issue of Leiden Papers in Linguistics 2.1*, M. Tzakosta, C. Levelt, & J. van de Weijer, eds., pp. 137-161.
- Velleman, S. L. & M. M. Vihman 2002. The optimal initial state. ROA 552.
- Weijer, J. v. d. 1993. The manner-place dependency in complex segments. *Linguistics*. vol. 31. pp. 87-110.
- Weismer, S. E., J. B. Tomblin, X. Zhang, P. Buchwalter, J. G. Chynoweth, & M. Jones 2000. Nonword repetition in school-age children with and without language impairment. *Journal of Speech, Language, and Hearing Research*. vol. 43. pp. 865-878.
- Wright, R. 2004. A review of perceptual cues and cue robustness. In *Phonetically based phonology*, B. Hayes, R. Kirchner, & D. Steriade, eds., Cambridge University Press, Cambridge, pp. 34-57.
- Yang, C. D. 2002. *Knowledge and learning in natural language*. Oxford University Press, New York.
- Yip, M. 2002. Perceptual influences in loanword phonology. In *The journal of the phonetic society of Japan. Special issue in aspects of loanwords phonology*, H. Kubozono, ed., pp. 4-21.
- Zamuner, T. & L. A. Gerken 1998. Young children's production of coda consonants in different prosodic environments. In *The proceedings of the twenty-ninth annual child language research forum*, E. V. Clark, ed., pp. 121-128.
- Zamuner, T., L. A. Gerken, & M. Hammond 2004. Phonotactic probabilities in young children's speech production. *Journal of child language*. vol. 31. pp. 515-536.

## Appendix

### 1. The Subjects

Child information (ordered by age)

<i>Child name</i>	<i>Sex</i>	<i>Age</i>	<i>Town</i>	<i>Nursery</i>
Epistimi	F	2;03;08	Rethymno	1
Vagelio	F	2;10;07	Rethymno	1
Emanouil	M	2;10;20	Iraklio	4
Lena	F	2;10;28	Iraklio	4
Nikolas	M	2;10;29	Iraklio	4
Kostantinos	M	2;11;17	Rethymno	1
Manouela	F	2;11;19	Rethymno	1
Antonia	F	2;11;20	Rethymno	3
Mirto	F	3;00	Iraklio	4
Dimitra	F	3;00;03	Rethymno	1
Kali	F	3;00;03	Rethymno	1
Manthos	M	3;00;19	Rethymno	1
Marios	M	3;01	Iraklio	4
Sofia	F	3;01	Rethymno	1
Fenia	F	3;01;04	Iraklio	4
Pantelis	M	3;01;29	Rethymno	3
Aglaia	F	3;03	Rethymno	2
Mario	F	3;03;01	Rethymno	2
Argiroula	F	3;04;01	Iraklio	4
Manos	M	3;04;04	Rethymno	1
Agelos	M	3;04;12	Rethymno	2
Fanouris	M	3;04;15	Rethymno	2
Giota	F	3;04;15	Rethymno	2
Maraki	F	3;05;03	Iraklio	4
Antonis	M	3;06;04	Rethymno	3
Eleni	F	3;06;16	Rethymno	2
Manolio	M	3;06;17	Rethymno	1

<i>Child name</i>	<i>Sex</i>	<i>Age</i>	<i>Town</i>	<i>Nursery</i>
Despina	F	3;06;29	Rethymno	1
Elisavet	F	3;07;14	Rethymno	3
Mariana	F	3;07;17	Rethymno	2
Stamatis	M	3;08;03	Rethymno	2
Maro	F	3;09;23	Iraklio	4
Manolis	M	3;10;01	Rethymno	1
Vasiliki	F	3;10;15	Rethymno	3
Vaso	F	3;10;25	Rethymno	2
Eirini	F	3;10;25	Rethymno	1
Marilena	F	3;10;27	Rethymno	1
Kaliopi	F	3;11;11	Rethymno	2
Kostantina	M	3;11;11	Rethymno	2
Stavros	M	3;11;24	Iraklio	4
Katerina	F	3;11;25	Rethymno	1
Thanos	M	3;11;26	Iraklio	4
Chrysa	F	4;00;03	Rethymno	2
Manolios	M	4;00;12	Rethymno	1
Giorgos	M	4;00;14	Rethymno	1
Argiro	F	4;01;17	Rethymno	1
Zoi	F	4;02;17	Rethymno	1
Kleri	F	4;03;06	Rethymno	1
Andreas	M	4;03;16	Iraklio	4
Nikos	M	4;03;17	Rethymno	1
Natalia	F	4;03;24	Rethymno	1
Mairi	F	4;04;01	Rethymno	3
Kostas	M	4;05	Rethymno	3
Dionisia	F	4;06;01	Rethymno	1
Mixaela	F	4;06;04	Rethymno	1
Maria	F	4;06;05	Rethymno	2
Georgia	F	4;08;15	Rethymno	1
Emanouela	F	4;11;21	Rethymno	-
Sotiria	F	5;00;16	Rethymno	2



## 2. Data sheets

### Order A

Child's name:

Age:

Test date:

Date of birth:

Tape:

<i>Target</i>	<i>Response</i>	<i>Target</i>	<i>Response</i>
1. t'iki		32. tfika	
2. lok'a		33. kixro	
3. ð'ipo		34. pitka	
4. pix'a		35. xtika	
5. tovði		36. ðvito	
6. rtika		37. tolki	
7. stipo		38. ɣðoki	
8. piska		39. kifθo	
9. flapi		40. kaxti	
10. kiɣvo		41. klito	
11. pofti		42. vɣapi	
12. karti		43. posti	
13. ltapi		44. rfipo	
14. sxika		45. tokti	
15. kispo		46. toðvi	
16. txipo		47. vripo	
17. kapti		48. povri	
18. spoki		49. xθapi	
19. pifla		50. katfi	
20. ɣvoki		51. skapi	
21. ptika		52. fθoki	
22. trika		53. tokli	
23. kiɣðo		54. ftipo	
24. kasxi		55. kilpo	
25. pilta		56. ktito	
26. sfito		57. lpoki	
27. pixθa		58. tkapi	
28. lkito		59. pivɣa	
29. xroki		60. tosfi	
30. potxi		61. vðito	
31. katri		62. porfi	

Other comments:

## Order B

Child's name:

Age:

Test date:

Date of birth:

Tape:

<i>Target</i>	<i>Response</i>	<i>Target</i>	<i>Response</i>
1. k'epa		32. spoki	
2. θok'i		33. porfi	
3. p'aði		34. vripo	
4. tep'a		35. vɣapi	
5. xtika		36. katfi	
6. rfipo		37. piska	
7. pifla		38. sfito	
8. toðvi		39. ɣðoki	
9. ɣvoki		40. tovði	
10. lkito		41. tfika	
11. tokli		42. lpoki	
12. kiyvo		43. katri	
13. sxika		44. skapi	
14. kilpo		45. vðito	
15. pivɣa		46. kapti	
16. flapi		47. potxi	
17. ptika		48. rtika	
18. pixθa		49. xθapi	
19. xroki		50. posti	
20. kasxi		51. pitka	
21. pofti		52. ftipo	
22. stipo		53. tolki	
23. karti		54. kaxti	
24. tkapi		55. ðvito	
25. tosfi		56. trika	
26. klito		57. ktito	
27. kifθo		58. povri	
28. kispo		59. txipo	
29. ltapi		60. pilta	
30. kixro		61. tokti	
31. kiyðo		62. fθoki	

Other comments:

## Order C

Child's name:

Age:

Test date:

Date of birth:

Tape:

<i>Target</i>	<i>Response</i>	<i>Target</i>	<i>Response</i>
1. tip'o		32. kispo	
2. l'opa		33. ltapi	
3. kir'o		34. vyapi	
4. v'ora		35. ptika	
5. flapi		36. skapi	
6. kiyvo		37. kixro	
7. povri		38. kapti	
8. sxika		39. vōito	
9. ðvito		40. spoki	
10. porfi		41. trika	
11. xθapi		42. ftipo	
12. tolki		43. tosfi	
13. txipo		44. γvoki	
14. posti		45. pixθa	
15. kifθo		46. katri	
16. xroki		47. lpoki	
17. xtika		48. pofti	
18. stipo		49. tokti	
19. tokli		50. lkito	
20. kasxi		51. fθoki	
21. tfika		52. katfi	
22. piska		53. pivya	
23. klito		54. rtika	
24. karti		55. potxi	
25. kiγðo		56. pilta	
26. tkapi		57. ktito	
27. pifla		58. rfipo	
28. sfito		59. tovði	
29. kaxti		60. kilpo	
30. pitka		61. vripo	
31. γðoki		62. toðvi	

Other comments:

### 3. Record of responses

#### Chapter 3

Table 1. TT clusters: general results

	<i>Word initial TT</i>		<i>Word medial TT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	124	42%	163	55.3%
Drops 2 <sup>nd</sup> cons.	23	7.8%	23	7.8%
Drops 1 <sup>st</sup> cons.	56	19%	45	15.3%
Other single cons.	29	9.8%	11	3.7%
Consonant epenthesis	4	1.4%	-	
Vowel epenthesis	-		-	
Metathesis	-		1	0.3%
Other cluster	16	5.4%	15	5.1%
Changes one con.	43	14.6%	37	12.5%
<b>Total</b>	295	100%	295	100%

Table 2. TT clusters: consonant deletion by cluster type

	<i>Word initial TT</i>		<i>Word medial TT</i>	
	Drops 1 <sup>st</sup> C	Drops 2 <sup>nd</sup> C	Drops 1 <sup>st</sup> C	Drops 2 <sup>st</sup> C
Fric-stop	20	0	15	2
Fric-fric	36	23	30	21
<b>Total</b>	56	23	45	23

Table 3. TT clusters: correct versus incorrect responses. Alternative criteria

	<i>Word initial TT</i>		<i>Word medial TT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	155	52.5%	198	67.1%
Incorrect	140	47.5%	97	35.9%
<b>Total</b>	295	100.0%	295	100.0%

Table 4. TR clusters: general results

	<i>Word initial TR</i>		<i>Word medial TR</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	176	59.7%	175	59.3%
Drops 2 <sup>nd</sup> cons.	52	17.6%	53	18.0%
Drops 1 <sup>st</sup> cons.	5	1.7%	1	0.3%
Other single cons.	26	8.8%	10	3.4%
Consonant epenthesis	1	0.3%	4	1.4%
Vowel epenthesis	3	1.0%	2	0.7%
Metathesis	0	0.0%	10	3.4%
Other cluster	7	2.4%	13	4.4%
Changes one con.	25	8.5%	27	9.2%
<b>Total</b>	295	100.0%	295	100.0%

Table 5. TR clusters: correct versus incorrect responses. Alternative criteria

	<i>Word initial TR</i>		<i>Word medial TR</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	204	69.2%	196	66.4%
Incorrect	91	30.8%	99	33.6%
<b>Total</b>	295	100.0%	295	100.0%

## Chapter 4

Table 6. sT clusters: general results

	<i>Word initial sT</i>		<i>Word medial sT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	177	60.4%	190	64.6%
Drops 2 <sup>nd</sup> cons.	19	6.5%	12	4.1%
Drops 1 <sup>st</sup> cons.	45	15.4%	48	16.3%
Other single cons.	16	5.5%	7	2.4%
Consonant epenthesis	3	1.0%	5	1.7%
Vowel epenthesis	-			
Metathesis	0	0.0%	1	0.3%
Other cluster	5	1.7%	9	3.1%
Changes one con.	28	9.6%	22	7.5%
<b>Total</b>	293	100.0%	294	100.0%

Table 7. sT clusters: consonant deletion by cluster type

	<i>Word initial sT</i>		<i>Word medial sT</i>	
	Drops 1 <sup>st</sup> C	Drops 2 <sup>nd</sup> C	Drops 1 <sup>st</sup> C	Drops 2 <sup>st</sup> C
s-stop	24	5	25	0
s-fric	21	14	23	12
<b>Total</b>	45	19	48	12

Table 8. sT clusters: correct versus incorrect responses by age

Age	<i>Word initial sT</i>			<i>Word medial sT</i>		
	Correct	Incorrect	Correct percentage	Correct	Incorrect	Correct percentage
Group 1: 2;03- 3;05	51	68	42.9%	59	60	49.6%
Group 2: 3;06-3;11	61	29	67.8%	65	25	72.2%
Group 3: 4;00-5;00	65	20	76.4%	66	19	77.6%

Table 9. sT clusters: correct versus incorrect responses. Alternative criteria

	<i>Word initial sT</i>		<i>Word medial sT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	191	65.2%	191	65%
Incorrect	102	34.8%	103	35%
<b>Total</b>	293	100.0%	294	100.0%

Table 10. Word medial TR clusters: correct versus incorrect responses by age group

Age	<i>Word medial TR</i>		
	Correct	Incorrect	Percentage correct
Group 1: 2;03- 3;05	53	67	44.2%
Group 2: 3;06-3;11	62	28	68.9%
Group 3: 4;00-5;00	60	25	70.6%

Table 11. RT clusters: general results

	<i>Word medial RT</i>	
	Number of responses	Response percentage
Correct	120	40.8%
Drops 2 <sup>nd</sup> cons.	0	0.0%
Drops 1 <sup>st</sup> cons.	110	37.4%
Other single cons.	11	3.7%
Consonant epenthesis	1	0.3%
Vowel epenthesis	7	2.4%
Metathesis	13	4.4%
Other cluster	12	4.1%
Changes one con.	20	6.8%
<b>Total</b>	294	100%

Table 12. Licensing versus government clusters: correct versus incorrect responses

	<i>Licensing clusters</i>	<i>Government clusters</i>		
	-TR	-sT	-TT	-RT
Correct	175	190	163	120
Incorrect	120	104	132	174
<b>Total</b>	295	294	295	294
Percentage correct	59.3%	53.6%		

Table 13. Government and licensing clusters: correct versus non-correct responses.

Alternative criteria

	<i>Licensing clusters</i>	<i>Government clusters</i>		
	-TR	-sT	-TT	-RT
Correct	196	214	206	144
Incorrect	99	80	89	150
Total	295	294	295	294
Percentage correct	66%	63.9%		

## Chapter 5

Table 14. Marked TT: general results

	<i>Word initial marked TT</i>		<i>Word medial marked TT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	56	23.7%	97	41.1%
Drops 2 <sup>nd</sup> cons.	17	7.2%	13	5.5%
Drops 1 <sup>st</sup> cons.	68	28.8%	23	9.7%
Other single cons.	23	9.7%	16	6.8%
Dissimilation	44	18.6%	46	19.5%
Other	28	11.9%	41	17.4%
<b>Total</b>	236	100.0%	236	100.0%

Table 15. Marked TT: correct versus incorrect responses. Alternative criteria

	<i>Word initial marked TT</i>		<i>Word medial marked TT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Correct	119	50.4%	179	75.8%
Incorrect	117	49.6%	57	24.2%
<b>Total</b>	236	100.0%	236	100.0%



Table 16. Marked TT: correct versus incorrect responses by cluster type

Age	<i>Word initial marked TT</i>			<i>Word medial marked TT</i>		
	Correct	Incorrect	Percentage correct	Correct	Incorrect	Percentage correct
Stop-stop	30	88	25.42%	69	49	58.47%
Fricative-fricative	26	92	22%	28	90	23.73%

Table 17. Marked TT: dissimilated responses. Alternative criteria

	<i>Word initial marked TT</i>		<i>Word medial marked TT</i>	
	Number of responses	Response percentage	Number of responses	Response percentage
Dissimilated	57	24.2%	58	24.6%
Other	179	75.8%	178	75.4%
<b>Total</b>	236	100.0%	236	100%

Table 18. Marked TT: correct versus dissimilated responses by age group. Alternative criteria

Age	<i>Word initial marked TT</i>			<i>Word medial marked TT</i>		
	Correct	Dissimil.	Percentage correct	Correct	Dissimil.	Percentage correct
Group 1: 2;03- 3;05	13	26	13.3%	28	28	50%
Group 2: 3;06-3;11	24	14	63.2%	44	15	74.6%
Group 3: 4;00-5;00	24	17	58.5%	45	17	72.6%

Table 19. Marked TT: correct versus dissimilated responses by nursery. Alternative criteria

Age	<i>Word initial marked TT</i>			<i>Word medial marked TT</i>		
	Correct	Dissimil.	Percentage correct	Correct	Dissimil.	Percentage correct
Nursery 1	26	22	54.2%	51	25	67.1%
Nursery 2	13	10	56.5%	28	14	66.7%
Nursery 3	10	13	43.5%	17	10	63.0%
Nursery 4	10	10	50%	17	9	65.4%